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A LIBRARY OF FAILURE REGIONS

Timothy J. Shimeall
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A Library of Failure Regions

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This report is a collection of the failure regions for the known faults in a collection of implementations of a combat simulation program. A failure region is the set of all possible program inputs that will execute a specific fault and produce a result that varies from the specified or expected result. A fault is an erroneous (possibly non-contiguous) section of program source code. The purpose of this report is to document a set of failure regions corresponding to the known faults in a set of redundant program versions.

Each failure regions is characterized in two ways: by identifying the fault that it reveals and by identifying the boolean conditions sufficient to consider a program input to be a member of the failure region. These boolean conditions are divided into three parts. Those labelled "Condition I" are the conditions that cause an input to execute the fault. Those labelled "Condition II" are the conditions that cause the execution of the fault to produce an erroneous internal state. Those labelled "Condition III" are the conditions that cause that erroneous internal state to be propagated to become part of a result. The process of determining these conditions is dealt with at length in a recent Master's Thesis[1].

There have been two simplifications made in the course of deriving the failure regions in this report. First, all uninitialized variables are assumed to have erroneous values. This simplification is made to avoid machine-dependent probabilistic modeling of the conditions under which a coincidentally correct value may be found in an uninitialized variable. Second, the effects that one failure region has on another have been neglected here. During the analysis process, each fault is considered in isolation of all other known faults in the code.

The failure regions in this report are for the known faults in eight implementations of CONFLICT, a simplified nonprobablistic combat simulation, that were developed in the course of a software experiment[2]. It is assumed that the reader is very familiar with the CONFLICT Specification[3]. All of the failure regions that follow arise from violations of that specification and all of the variables and many of the conditions described below are abstracted from the specification or from the implementations of that specification.

The regions in this report are profiled and analyzed in an accompanying document[4].

References

- [1] Bolchoz, J. M., 'The Identification of Software Failure Regions', M.S. Thesis, Computer Science Dept., Naval Postgraduate School, Monterey, CA, 1990.
- [2] Shimeall, T. J. and Leveson, N. G., 'An Empirical Comparison of Software Fault Tolerance and Fault Elimination', *IEEE Transactions on Software Engineering*, Vol. SE-17, No. 2, February 1991, pp. 173–182.
- [3] Shimeall, T. J., 'CONFLICT Specification', Technical Report No. NPSCS-91-001, Computer Science Dept., Naval Postgraduate School, Monterey, CA, 1991.
- [4] Shimeall, T. J., Bolchoz, J. M. and Griffin, R., 'Analytical Derivation of Software Failure Regions'. Technical Report No. NPSCS-91-003, Computer Science Dept., Naval Postgraduate School, Monterey, CA, 1991.

Notation

In the descriptions that follow, the following conventions are used:

- So far as is possible, the conventions of the specification have been preserved.
- Text appearing in italics (e.g. '*Endurance*') are defined within the scope of this document, either globally or for a specific failure region.
- Text appearing in roman type (e.g. '*Army[]*.Endurance') are program variables for the implementations containing the fault. The only exception to this is the variable 'Mainloop', which is used to indicate the current simulation cycle, but may not appear in a specific version under that name. 'Mainloop' is normally defined within the *Active* predicate, implicitly existentially quantified.
- Due to the fact that program variables are more than one character in length, all multiplication is shown explicitly with the multiplication symbol \times .
- Due to the length of the formulae below, it is necessary to break formulae across more than one line. There are no matrix or vector operations appearing in this document, and parentheses are used strictly to delimit portions of formulae to improve readability or to indicate precedence of operations.
- All definitions within 'Condition I' of a failure region are assumed to extend over 'Condition II' and 'Condition III' of that failure region unless use of parentheses indicates otherwise. All definitions within 'Condition II' of a failure region are similarly assumed to extend over 'Condition III' of that failure region.
- The diacritical marks ' and " are used strictly to distinguish between variables of similar name and role in a given failure region.

Time-Dependent Definitions

Endurance of Squadron (B, g, j) at time t :

$$\begin{aligned} \text{Endurance}(B, g, j, t) = & \text{Army}[B, g].\text{Endurance}[j] - \\ & \text{Army}[B, g].\text{Wear}[j] \times t - \\ & \text{Damage}(B, g, j, t - 1) + \text{Repair}(B, g, j, t - 1) \end{aligned}$$

Weapon Damage of Squadron (B, g, j) up to and including time t :

$$\text{Damage}(B, g, j, t) = \begin{cases} 0 & \text{if } t \leq 1 \\ \text{Damage}(B, g, j, t - 1) + \\ \sum_{e=1}^{\text{NArmy}[\neg B]} \left(\sum_{w=1}^{\text{Params.NumWTypes}} \left(\sum_{i=1}^{\text{Army}[\neg B, e].\text{Weapon}[w].\text{NumWeapon}} \right. \right. \\ \left. \left. \begin{aligned} & \text{Army}[\neg B, e].\text{Weapon}[w].\text{Damage} \times \\ & \text{Army}[\neg B, g].\text{WeapSensativity}[w] \times \\ & \max \left(0, 1 - \frac{\sqrt{(x_{B, g, j}(t - 1) - ax_{\neg B, e, w, i}(t - 1))^2 +} \right. \\ & \left. \left. (y_{B, g, j}(t - 1) - ay_{\neg B, e, w, i}(t - 1))^2}{\text{Army}[\neg B, e].\text{Weapon}[w].\text{Radius}} \right) \right) \right) \right) \end{aligned} \right) & \text{otherwise} \end{cases}$$

Whether or not Squadron (B, g, j) is a casualty at time t :

$$\begin{aligned} \text{Casualty}(B, g, j, t) \equiv & (\text{Endurance}(B, g, j, t - 1) > 0) \wedge \\ & \left(\frac{\text{Endurance}(B, g, j, t - 1)}{\text{Army}[B, g].\text{Endurance}[j]} \leq 0.5 \right) \end{aligned}$$

Repair applied to Squadron (B, g, j) up to and including time t :

$$\text{Repair}(B, g, j, t) = \begin{cases} 0 & \text{if } t \leq 1 \\ \text{Repair}(B, g, j, t - 1) & \text{if } (t > 1) \wedge \neg \text{Casualty}(B, g, j, t - 1) \\ \text{Repair}(B, g, j, t - 1) + \\ \min(\text{Suppl}(B, g, t - 1) / \text{NumCas}(B, g, t), \\ \text{FixRate}(B, g, t - 1) / \text{NumCas}(B, g, t), \\ (\text{Army}[B, g].\text{Endurance}[j] \\ - \text{Endurance}(B, g, j, t - 1) \\ - \text{Repair}(B, g, j, t - 1) \\ + \text{Repair}(B, g, j, t - 2))) & \text{otherwise} \end{cases}$$

Number of Casualties in Battalion B, g at time t :

$$\text{NumCas}(B, g, t) = \sum_{j=1}^{\text{Army}[B, g].\text{Squadrons}} \begin{cases} 1 & \text{if } \text{Casualty}(B, g, j, t - 1) \\ 0 & \text{otherwise} \end{cases}$$

Rate of Repair available to any squadron of battalion B, g at time t :

$$FixRate(B, g, t) = Army[B, g].FixRate \times NumFix(B, g, t - 1)$$

Number of Squadrons in battalion B, g dedicated to repair other squadrons at time t :

$$NumFix(B, g, t) = Army[B, g].NumFixers \times \frac{\sum_{j=1}^{Army[B, g].Squadrons} \begin{cases} 0 & \text{if } \neg Casualty(B, g, j, t) \\ 1 & \text{otherwise} \end{cases}}{Army[B, g].Squadrons}$$

Amount of supplies available in battalion B, g at time t :

$$Suppl(B, g, t) = Army[B, g].FixSuppl - \sum_{j=1}^{Army[B, g].Squadrons} Repair(B, g, j, t - 1)$$

X Location of Battalion B, g at time t :

$$\begin{aligned} x_{B, g}(t) = & Army[B, g].X + \\ & \sum_{d=1}^t (V(B, g, d) \times \cos(Army[B, g].Theta) \\ & \times TM(B, g, x_{B, g}(d - 1), y_{B, g}(d - 1), V(B, g, d - 1)) \\ & \times WM(B, g, x_{B, g}(d - 1), y_{B, g}(d - 1), d)) \end{aligned}$$

Y Location of Battalion B, g at time t :

$$\begin{aligned} y_{B, g}(t) = & Army[B, g].Y + \\ & \sum_{d=1}^t (V(B, g, d) \times \sin(Army[B, g].Theta) \\ & \times TM(B, g, x_{B, g}(d - 1), y_{B, g}(d - 1), V(B, g, d - 1)) \\ & \times WM(B, g, x_{B, g}(d - 1), y_{B, g}(d - 1), d)) \end{aligned}$$

Velocity of Battalion B, g at time t :

$$V(B, g, t) = \min_{j=1}^{Army[B, g].Squadrons} \begin{cases} \infty & \text{if } Endurance(B, g, j, t - 1) \leq 0 \\ Army[B, g].V0[j] \times \frac{Endurance(B, g, j, t - 1)}{Army[B, g].Endurance[j]} & \text{otherwise} \end{cases}$$

Terrain effect on Movement of Battalion B, g at location x, y moving at velocity v :

Let x' and y' represent the end of the possible movement, p, q be the Terrain grid location of x, y :

$$x' = x + v \times \cos(\text{Army}[B, g].\text{Theta})$$

$$y' = y + v \times \sin(\text{Army}[B, g].\text{Theta})$$

$$p(x) = \left\lfloor \frac{x}{\text{Params.XDelta}} \right\rfloor$$

$$q(y) = \left\lfloor \frac{y}{\text{Params.YDelta}} \right\rfloor$$

$$TM(B, g, x, y, v) = \begin{cases} 0 & \text{if } v = 0 \\ \max \left(0, \frac{\text{Army}[B, g].\text{MaxSlope} - \frac{\text{Alt}(p(x'), q(y')) - \text{Alt}(p(x), q(y))}{\sqrt{(x' - x)^2 + (y' - y)^2}}}{\text{Army}[B, g].\text{MaxSlope}} \right) & \text{otherwise} \end{cases}$$

Weather effect on Movement of Battalion B, g at location x, y at time t :

Let (WX_i, WY_i) be the center location of storm i at time t :

$$WX_i = \begin{cases} \text{Weather}[i].WX0 & \text{if } t < \text{Weather}[i].TStart \vee t > \text{Weather}[i].TEnd \\ \text{Weather}[i].WX0 + (t - \text{Weather}[i].TStart) \times \text{Weather}[i].dWX & \text{otherwise} \end{cases}$$

$$WY_i = \begin{cases} \text{Weather}[i].WY0 & \text{if } t < \text{Weather}[i].TStart \vee t > \text{Weather}[i].TEnd \\ \text{Weather}[i].WY0 + (t - \text{Weather}[i].TStart) \times \text{Weather}[i].dWY & \text{otherwise} \end{cases}$$

Let W be the total effect of storms on location (x, y) at time t :

$$W(x, y, t) = \sum_{i=1}^{\text{Params.NumWEvents}} \begin{cases} 0 & \text{if } t < \text{Weather}[i].TStart \vee t > \text{Weather}[i].TEnd \\ \max \left(0, \frac{\text{Weather}[i].WRadius - \sqrt{(x - WX_i)^2 + (y - WY_i)^2}}{\text{Weather}[i].WRadius} \times \right) & \text{otherwise} \end{cases}$$

$$WM(B, g, x, y, t) = \begin{cases} 1 & \text{if } W(x, y, t) = 0 \\ \text{Army}[B, g].MWEff \times \left| \frac{W(x, y, t) - \text{Params.WMaxSeverity} \times \text{Params.NumWEvents}}{\text{Params.WMaxSeverity} \times \text{Params.NumWEvents}} \right| & \text{otherwise} \end{cases}$$

Weather effect on Observation at location (x, y) at time t :

$$WO(x, y, t) = \begin{cases} 0 & \text{if } W(x, y, t) = 0 \\ \left| \frac{W(x, y, t) - \text{Params.WMaxSeverity} \times \text{Params.NumWEvents}}{\text{Params.WMaxSeverity} \times \text{Params.NumWEvents}} \right| & \text{otherwise} \end{cases}$$

(X, Y) Location of Squadron B, g, j at time t :

Let s be the number of Squadrons in Battalion B, g prior to squadron j that have positive endurance at time t :

$$s(B, g, j, t) = \sum_{i=1}^{j-1} \begin{cases} 0 & \text{if } \text{Endurance}(B, g, i, t-1) \leq 0 \\ 1 & \text{otherwise} \end{cases}$$

$$x_{B,g,j}(t) = \begin{cases} x_{B,g}(t-1) + \text{Army}[B, g].\text{SquadSep} \times \left(s(B, g, j, t) - \left\lfloor \frac{s(B, g, j, t)}{\text{Army}[B, g].\text{GRow}} \right\rfloor \times \text{Army}[B, g].\text{GRow} \right) - \frac{\text{Army}[B, g].\text{GRow} \times \text{Army}[B, g].\text{SquadSep}}{2} & \text{if } s(B, g, \text{Army}[B, g].\text{Squadron} + 1, t) - s(B, g, j, t) > \text{Army}[B, g].\text{GRow} \\ x_{B,g}(t-1) + \text{Army}[B, g].\text{SquadSep} \times \left(s(B, g, j, t) - \left\lfloor \frac{s(B, g, j, t)}{\text{Army}[B, g].\text{GRow}} \right\rfloor \times \text{Army}[B, g].\text{GRow} \right) - \frac{s(B, g, \text{Army}[B, g].\text{Squadron} + 1, t) - \left\lfloor \frac{s(B, g, \text{Army}[B, g].\text{Squadron} + 1, t)}{\text{Army}[B, g].\text{GRow}} \right\rfloor \times \text{Army}[B, g].\text{GRow}}{2} & \text{otherwise} \end{cases}$$

$$y_{B,g,j}(t) = y_{B,g}(t-1) + \text{Army}[B, g].\text{RowSep} \times \left\lfloor \frac{s(B, g, j, t)}{\text{Army}[B, g].\text{GRow}} \right\rfloor - 0.5 \times \left\lfloor \frac{s(B, g, \text{Army}[B, g].\text{Squadron} + 1, t)}{\text{Army}[B, g].\text{GRow}} \right\rfloor \times \text{Army}[B, g].\text{RowSep}$$

Squadron B, g, j observes squadron $\neg B, e, k$ at time t :

$$\text{Observe}(B, g, j, e, k, t) \equiv \text{BigEnough}(B, g, j, e, k, t) \wedge \text{Clear}(B, g, j, e, k, t) \\ \wedge \text{Obvious}(B, g, j, e, k, t)$$

Squadron $\neg B, e, k$ is large enough to be seen at the distance from squadron B, g, j at time t :

$$\text{BigEnough}(B, g, j, e, k, t) \equiv \\ xgj = x_{B,g,j}(t-1) \wedge ygj = y_{B,g,j}(t-1) \wedge \\ xek = x_{\neg B,e,k}(t-1) \wedge yek = y_{\neg B,e,k}(t-1) \wedge \\ \left(\max \left\{ \tan^{-1} \left(\frac{y'-y}{x'-x} \right) - \tan^{-1} \left(\frac{y''-y}{x''-x} \right) \right| \right. \\ \left. (x', y'), (x'', y'') \in \{(xek \pm \text{Army}[\neg B, e].\text{SquadWidth}/2, \right. \\ \left. yek \pm \text{Army}[\neg B, e].\text{SquadLength}/2)\} \right. \\ \left. \geq \text{Army}[B, g].\text{ObsMinAngle}[j] \right)$$

No terrain blocks the view of squadron $\neg B, e, k$ from the position of squadron B, g, j at time t :

$$\text{Clear}(B, g, j, e, k, t) \equiv \\ xgj = x_{B,g,j}(t-1) \wedge ygj = y_{B,g,j}(t-1) \wedge \\ xek = x_{\neg B,e,k}(t-1) \wedge yek = y_{\neg B,e,k}(t-1) \wedge \\ (\forall a, a', c, c', z, z', a = \left\lfloor \frac{xgj}{\text{Params.XDelta}} \right\rfloor \wedge a' = \left\lfloor \frac{xek}{\text{Params.XDelta}} \right\rfloor \wedge \\ c = \left\lfloor \frac{ygj}{\text{Params.YDelta}} \right\rfloor \wedge c' = \left\lfloor \frac{yek}{\text{Params.YDelta}} \right\rfloor \wedge \\ z = \text{Alt}(a, c, xgj, ygj) \wedge z' = \text{Alt}(a', c', xek, yek) \wedge \\ (\forall n, 1 \leq n < \text{Params.SampleRate} - 1, \\ (\exists r, p, q, r = \frac{n}{\text{Params.SampleRate} - 1}, p = \left\lfloor \frac{xgj + r \times (xek - xgj)}{\text{Params.XDelta}} \right\rfloor, q = \left\lfloor \frac{ygj + r \times (yek - ygj)}{\text{Params.YDelta}} \right\rfloor, \\ (z + r \times (z' - z)) > \text{Alt}(p, q, xgj + r \times (xek - xgj), ygj + r \times (yek - ygj)) \\)))$$

Squadron $\neg B, e, k$ differs enough from its background to be discerned by squadron B, g, j at time t :

$$\begin{aligned}
& \text{Obvious}(B, g, j, e, k, t) \equiv \\
& \quad xgj = x_{B,g,j}(t-1) \wedge ygj = y_{B,g,j}(t-1) \wedge \\
& \quad xek = x_{\neg B,e,k}(t-1) \wedge yek = y_{\neg B,e,k}(t-1) \wedge \\
& \quad \left(\left(\frac{BI(a',c',xek,yek) - \text{Army}[\neg B,e].\text{SquadIntensity}[k]}{\text{Params.SampleRate}} \right. \right. \\
& \quad \sum_{n=1}^{\text{Params.SampleRate}} \left(\left(WO \left(xgj \times \frac{n \times (xek - xgj)}{\text{Params.SampleRate}}, ygj \times \frac{n \times (yek - ygj)}{\text{Params.SampleRate}}, \text{Mainloop} \right) \times \right. \right. \\
& \quad \quad \quad \left. \left. \text{Army}[B,g].\text{VWEffEffect} \right) + \right. \\
& \quad \quad \quad \left. \left. \begin{cases} 0 & \text{if } \sqrt{\left(x_{\neg B,e'}(\text{Mainloop} - 1) - xgj \times \frac{n \times (xek - xgj)}{\text{Params.SampleRate}} \right)^2 + \left(y_{\neg B,e'}(\text{Mainloop} - 1) - ygj \times \frac{n \times (yek - ygj)}{\text{Params.SampleRate}} \right)^2} \right. \right. \\
& \quad \quad \quad \left. \left. > \text{Army}[\neg B, e']. \text{ObsJamRadius} \right. \right. \\
& \quad \quad \quad \left. \left. \sum_{e'=1}^{N\text{Army}[\neg B]} \left\{ \begin{aligned} & \sqrt{\left(x_{\neg B,e'}(\text{Mainloop} - 1) - xgj \times \frac{n \times (xek - xgj)}{\text{Params.SampleRate}} \right)^2 + \left(y_{\neg B,e'}(\text{Mainloop} - 1) - ygj \times \frac{n \times (yek - ygj)}{\text{Params.SampleRate}} \right)^2} \right. \\ & \left. \left. \frac{\text{Army}[\neg B, e']. \text{ObsJamRadius}}{\text{Army}[\neg B, e']. \text{ObsJamEff}} \text{ otherwise} \right. \right. \right. \\
& \quad \quad \quad \left. \left. \right) \right) < \text{Army}[B, g]. \text{ObsMinContrast}[j] \right)
\end{cases}
\end{aligned}$$

Squadron $\neg B, e, k$ is in range of the weapons of battalion B, g at time t :

$$\begin{aligned}
& \text{InRange}(B, g, e, k, t) \equiv \\
& \quad xek = x_{\neg B,e,k}(t-1) \wedge yek = y_{\neg B,e,k}(t-1) \wedge \\
& \quad \sqrt{(xek - x_{B,g}(t-1))^2 + (yek - y_{B,g}(t-1))^2} < \text{Army}[B, g]. \text{Weapon}[i]. \text{Range}
\end{aligned}$$

Number of Squadrons in battalion B, g dedicated to processing messages at time t :

$$\text{NumProcess}(B, g, t) = \text{Army}[B, g]. \text{NumProcess} \times \frac{\text{NumCas}(B, g, t)}{\text{Army}[B, g]. \text{Squadrons}}$$

Number of Squadrons in battalion B, g dedicated to receiving messages at time t :

$$\text{NumRec}(B, g, t) = \text{Army}[B, g]. \text{NumReceive} \times \frac{\text{NumCas}(B, g, t)}{\text{Army}[B, g]. \text{Squadrons}}$$

Number of Squadrons in battalion B, g dedicated to communications jamming at time t :

$$\text{NumJam}(B, g, t) = \text{Army}[B, g]. \text{NumJammers} \times \frac{\text{NumCas}(B, g, t)}{\text{Army}[B, g]. \text{Squadrons}}$$

Number of Squadrons in battalion B, g dedicated to sending communications at time t :

$$\text{NumSend}(B, g, t) = \text{Army}[B, g]. \text{NumSend} \times \frac{\text{NumCas}(B, g, t)}{\text{Army}[B, g]. \text{Squadrons}}$$

Number of functional weapons of type i in battalion B, g at time t :

$$\text{NumWeapon}(B, g, i, t) = \text{Army}[B, g]. \text{Weapon}[i]. \text{NumWeapon} \times \frac{\text{NumCas}(B, g, t)}{\text{Army}[B, g]. \text{Squadrons}}$$

Target coordinates for weapon i of type w in Battalion B, g at time t :

$$\begin{aligned}
ax_{B,g,w,i}(t) &= x_{\neg B,e,k} \ni \\
&\left(\left(\sum_{e'=1}^{e-1} \sum_{k'=1}^{\text{Army}} [\neg B, e']. \text{Squadrons} \begin{cases} 1 & \text{if } \exists j, \text{Observe}(B, g, j, e', k', t-1) \\ 0 & \text{otherwise} \end{cases} \right) \right. \\
&+ \left. \left(\sum_{k'=1}^{k-1} \begin{cases} 1 & \text{if } \exists j, \text{Observe}(B, g, j, e, k', t-1) \\ 0 & \text{otherwise} \end{cases} \right) \right) = \\
&\left(\sum_{w'=1}^{w-1} \text{NumWeapon}(B, g, w', t) \right) + i - 1
\end{aligned}$$

$$\begin{aligned}
ay_{B,g,w,i}(t) &= y_{\neg B,e,k} \ni \\
&\left(\left(\sum_{e'=1}^{e-1} \sum_{k'=1}^{\text{Army}} [\neg B, e']. \text{Squadrons} \begin{cases} 1 & \text{if } \exists j, \text{Observe}(B, g, j, e', k', t-1) \\ 0 & \text{otherwise} \end{cases} \right) \right. \\
&+ \left. \left(\sum_{k'=1}^{k-1} \begin{cases} 1 & \text{if } \exists j, \text{Observe}(B, g, j, e, k', t-1) \\ 0 & \text{otherwise} \end{cases} \right) \right) = \\
&\left(\sum_{w'=1}^{w-1} \text{NumWeapon}(B, g, w', t) \right) + i - 1
\end{aligned}$$

Command Message m Implemented in Battalion B, g before time t :

$$\begin{aligned}
Mimp(B, g, m, t) &\equiv \\
&((\text{Cmsgs}[B, m].\text{Time} + \text{Army}[B, g].\text{MediaDelay} \\
&+ \text{RecDelay}(B, g, \text{RecT}(B, g, m)) + \text{QueDelay}(B, g, m) \\
&+ \text{Army}[B, g].\text{ProcDelay}) < t) \wedge \\
&(\text{Cmsgs}[B, m].\text{Dest} = g)
\end{aligned}$$

Delay due to message receipt at battalion B, g at time t :

$$\text{RecDelay}(B, g, t) = \begin{cases} \infty & \text{if } \text{NumRec}(B, g, t) - \text{ComJam}(B, g, t) \leq 0 \\ \frac{\text{Army}[B, g].\text{RecRate}}{\text{NumRec}(B, g, t) - \text{ComJam}(B, g, t)} & \text{otherwise} \end{cases}$$

Number of jammed receivers in battalion B, g at time t :

$$\begin{aligned}
\text{ComJam}(B, g, t) &= \\
&\sum_{e=1}^{\text{NArmy}[\neg B]} \min(\text{NumJam}(\neg B, e, t), \text{Army}[\neg B, e].\text{CommJamPriority}[g]) \times \\
&\text{Army}[\neg B, e].\text{CommJamEff} \times \\
&\max\left(0, \frac{\text{Army}[\neg B, e].\text{CommJamRadius} - \sqrt{(x_{\neg B,e}(t-1) - x_{B,g}(t-1))^2 + (y_{\neg B,e}(t-1) - y_{B,g}(t-1))^2}}{\text{Army}[\neg B, e].\text{CommJamRadius}}\right)
\end{aligned}$$

Delay due to message queuing of command message m in Battalion B, g :

$$\text{QueDelay}(B, g, m) = \sum_{t=\text{RecT}(B, g, m)}^{\text{Duration}} \begin{cases} 1 & \text{if } \text{CmdSum}(B, g, m, t) + \text{ReptSum}(B, g, m, t) \\ & \geq \text{NumProcess}(B, g, t-1) \\ 0 & \text{otherwise} \end{cases}$$

Time command message m is received at battalion B, g :

$$RecT(B, g, m) = Cmsgs[B, m].Time + Army[B, g].MediaDelay$$

Time delay for report message from battalion B, f to be transmitted to battalion B, g :

$$RepT(B, g, f) = Army[B, f].SendRate + Army[B, g].MediaDelay$$

Number of command messages, other than m being processed by battalion B, g at time t :

$$CmdSum(B, g, m, t) = \sum_{n=1}^{NCmsgs[B]} \begin{cases} 0 & \text{if } (m = n) \vee (Cmsgs[B, n].Dest \neq g) \vee \\ & (t \leq RecT(B, g, n) \wedge \\ & Cmsgs[B, m].Priority > Cmsgs[B, n].Priority) \\ & \vee (Cmsgs[B, n].Time > t) \vee \\ & (RecT(B, g, n) + Army[B, g].ProcDelay < t) \\ 1 & \text{otherwise} \end{cases}$$

Some opposing squadron exists and is observed by a squadron of B, g , at time t :

$$\begin{aligned} SomeObserve(B, g, t) &\equiv \\ (\exists e, 1 \leq e \leq Narmy[\neg B], Army[\neg B, e].Squadrons > 0 \wedge EObserve(B, g, e, t)) \end{aligned}$$

Some opposing squadron in battalion $\neg B, e$, exists and is observed by some squadron of B, g at time t .

$$\begin{aligned} EObserve(B, g, e, t) &\equiv \\ (\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, t) > 0 \wedge \\ (\exists j, 1 \leq j \leq Army[B, f].Squadrons, \\ Endurance(B, f, j, t) > 0 \wedge Observe(B, g, j, e, k, t))) \end{aligned}$$

Number of report messages being processed by battalion B, g at time t , while message m may be queued:

$$ReptSum(B, g, m, t) = \sum_{f=1}^{NArmy[B]} \begin{cases} 0 & \text{if } (Army[B, f].Report \neq g) \vee \\ & (\forall t', t - RepT(B, g, f) - Army[B, g].ProcDelay \\ & \leq t' \leq t - RepT(B, g, f), \\ & \neg SomeObserve(B, f, t')) \vee \\ & (SomeObserve(B, f, t - RepT(B, g, f)) \wedge \\ & Army[B, f].Priority < Cmsgs[B, m].Priority) \\ 1 & \text{otherwise} \end{cases}$$

Global Definitions

Battalion B , g is active:

$$\begin{aligned} Active(B, g) \equiv & ((Duration > 0) \wedge (Mainloop \in \{0 \dots Duration\}) \wedge \\ & (B \in \{TRUE, FALSE\}) \wedge (NArmy[B] > 0) \wedge \\ & (g \in \{1 \dots NArmy[B]\}) \wedge (Army[B, g].Squadrons > 0) \wedge \\ & (\exists i, 1 \leq i \leq Army[B, g].Squadrons, \\ & Endurance(B, g, i, Mainloop) > 0)) \end{aligned}$$

Altitude at position (x, y) in Terrain grid (p, q) :

$$\begin{aligned} Alt(p, q, x, y) = & \left(\frac{Terrain[p, q] - Terrain[p + 1, q] -}{Params.XDelta \times Params.YDelta} \times x \times y \right) + \\ & \left(\frac{(q(Terrain[p, q + 1] - Terrain[p + 1, q + 1]) - (q + 1)(Terrain[p, q] - Terrain[p + 1, q]))}{Params.XDelta} \times x \right) + \\ & \left(\frac{(p(Terrain[p + 1, q] - Terrain[p + 1, q + 1]) - (p + 1)(Terrain[p, q] - Terrain[p, q + 1]))}{Params.YDelta} \times y \right) + \\ & (p + 1)((q + 1)Terrain[p, q] - qTerrain[p, q + 1]) - \\ & p((q + 1)Terrain[p + 1, q] - qTerrain[p + 1, q + 1]) \end{aligned}$$

Background Intensity at position (x, y) in Terrain grid (p, q) :

$$\begin{aligned} BI(p, q, x, y) = & \sqrt{\left(\frac{Terrain[p, q + 1] - Terrain[p, q] + Terrain[p + 1, q + 1] - Terrain[p + 1, q]}{2(Params.XDelta)} \right)^2 +} \\ & \left(\frac{Terrain[p + 1, q + 1] - Terrain[p, q + 1] + Terrain[p + 1, q] - Terrain[p, q]}{2(Params.YDelta)} \right)^2} \\ & \times Params.ISlopeFactor + \\ & Params.IAltFactor \frac{Params.IMeanAlt - Alt(p, q, x, y)}{Params.IMeanAlt} + \\ & Params.IX \times x + Params.IY \times y + Params.IC \end{aligned}$$

Failure Regions in Version 1

1.1: Incorrect handling of NumCas when Army.Squadrons=0 initially

Condition I:

$$\text{Duration} > 0 \wedge (\exists B, B \in \{\text{true}, \text{false}\}, \text{NArmy}[B] > 0$$

Condition II:

$$(\exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B, g].\text{Squadrons} = 0))$$

Condition III: True

1.2: Update always implements commands ready at the same time in CMsgs array order

Condition I:

$$\begin{aligned} & \text{Active}(B, g) \wedge \\ & (\exists m, n, 1 \leq m \leq \text{NCmsgs}[B], 1 \leq n \leq \text{NCmsgs}[B], m < n \wedge \\ & \quad \text{Mimp}(B, g, m, \text{Mainloop}) \wedge \neg \text{Mimp}(B, g, m, \text{Mainloop} - 1) \wedge \\ & \quad \text{Mimp}(B, g, n, \text{Mainloop}) \wedge \neg \text{Mimp}(B, g, n, \text{Mainloop} - 1)) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{Priority} < \text{Cmsgs}[B, n].\text{Priority} \wedge \text{Cmsgs}[B, m].\text{msg} \neq \text{Cmsgs}[B, n].\text{msg}$$

Condition III:

$$\begin{aligned} & (\nexists i, 1 \leq i \leq \text{NCmsgs}[B], i \neq m \wedge i \neq n \wedge \\ & \quad \text{Mimp}(B, g, i, \text{Duration}) \wedge \neg \text{Mimp}(B, g, i, \text{Mainloop} - 1))) \end{aligned}$$

1.3: Over-restrictive check: positive dWX

Condition I: Params.NumWEvents > 0

Condition II:

$$\exists i, 1 \leq i \leq \text{Params.NumWEvents}, \text{Weather}[i].\text{dWX} < 0$$

Condition III: True

1.4: Over-restrictive check: positive dWY

Condition I: $\text{Params.NumWEvents} > 0$

Condition II:

$$\exists i, 1 \leq i \leq \text{Params.NumWEvents}, \text{Weather}[i].\text{dWY} < 0$$

Condition III: True

1.5: Garbage value in FixSuppl when Fix Supplies exhausted

Condition I:

$$\text{Active}(B, g) \wedge (\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Casualty}(B, g, j, \text{Mainloop}))$$

Condition II:

$$\left(\sum_{i=1}^{\text{Army}[B, g].\text{Squadrons}} \text{Repair}(B, g, i, \text{Mainloop}) \right) \geq \text{Army}[B, g].\text{FixSuppl}$$

Condition III:

$$(\nexists i, 1 \leq i \leq \text{NCmsgs}[B], \text{Mimp}(B, g, i, \text{Duration}) \wedge \neg \text{Mimp}(B, g, i, \text{Mainloop} - 1))$$

1.6: Spurious input check requiring IAF > 0

Condition I: True

Condition II: $\text{Params.IAltFactor} \leq 0$

Condition III: True

1.7: Spurious Input check requiring NumWEvents > 0

Condition I: True

Condition II: $\text{Params.NumWEvents} \leq 0$

Condition III: True

1.8: Negative NW value

Condition I:

$$\begin{aligned} & \exists B, g, e, t, Active(B, g) \wedge Active(\neg B, e) \wedge 1 < t < Mainloop \wedge \\ & (\exists j, k, 1 \leq k \leq Army[\neg B, e].Squadrons \wedge 1 \leq j \leq Army[B, g].Squadrons \wedge \\ & Endurance(B, g, j, t) > 0 \wedge Endurance(\neg B, e, k, t) > 0 \wedge Observe(B, g, j, e, k, t)) \wedge \\ & Params.NumWTypes > 1 \end{aligned}$$

Condition II:

$$\begin{aligned} & \exists i, 1 \leq i \leq Params.NumWTypes, Army[B, g].WeapPriority[e, i] < 0 \vee \\ & NumWeapon(B, g, i, Mainloop) \\ & < (NumWeapon(B, g, i, Mainloop - 1) - NumWeapon(B, g, i, Mainloop) + \\ & \left[\frac{\sum_{n=1}^{Mainloop \wedge Army[\neg B]} \sum_{e'=1} \left(\min(|\{k' \exists j, Observe(B, g, j, e', k', n - 1)\}|, \right. \right.}{Army[B, g].WeapPriority[e', i],} \\ & \left. \left. \frac{NumWeapon(B, g, i, n))}{NumWeapon(B, g, i, Mainloop - 1)} \right) \right] \end{aligned}$$

Condition III:

$$\begin{aligned} & (\neg \exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Duration) \wedge \neg Mimp(B, g, m, Mainloop - 1)) \wedge \\ & (\neg \exists m, 1 \leq m \leq NCmsgs[\neg B], Mimp(\neg B, e, m, Duration) \wedge \\ & \neg Mimp(\neg B, e, m, Mainloop - 1)) \end{aligned}$$

1.9: PSentListLoc sends out of range squadron to SquadAlive

Condition I:

$$\begin{aligned} & Active(B, g) \wedge Active(\neg B, e) \wedge Active(B, f) \wedge Army[B, f].Report = g \wedge \\ & (\exists t, 1 \leq t \leq Duration, \\ & t = Mainloop - RepT(B, f, g) - Army[B, g].ProcDelay \\ & - \frac{Army[B, g].RecRate}{NumRec(B, g, Mainloop - Army[B, g].ProcDelay)} \wedge \\ & (\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, (\exists j, 1 \leq j \leq Army[B, f].Squadrons, \\ & Observe(B, f, j, e, k, t) \wedge Endurance(\neg B, e, k, t) > 0)) \end{aligned}$$

Condition II:

$$\begin{aligned} & (\exists m, 1 \leq m \leq NCmsgs[\neg B], (\neg Mimp(\neg B, e, m, t)) \wedge Mimp(\neg B, e, m, Mainloop) \wedge \\ & Army[\neg B, e].Squadrons > Cmsgs[\neg B, m].msg.Squadrons)) \end{aligned}$$

Condition III: True

1.10: Restriction that SquadIntensity>0

Condition I:

$$\begin{aligned} &(\exists B, B \in \{\text{true}, \text{false}\}, \text{NArmy}[B] > 0 \wedge \\ &(\exists g, g \in \{1 \dots \text{NArmy}[B]\}, \text{Army}[B, g].\text{Squadrons} > 0 \\ &\wedge (\exists j, j \in \{1 \dots \text{Army}[B, g].\text{Squadrons}\}, \end{aligned}$$

Condition II:

$$\text{Army}[B, g].\text{SquadIntensity}[j] \leq 0)))$$

Condition III: True

1.11: Restriction that FixSuppl ≥ 0

Condition I:

$$\begin{aligned} &(\exists B, B \in \{\text{true}, \text{false}\}, \text{NArmy}[B] > 0 \wedge \\ &(\exists g, g \in \{1 \dots \text{NArmy}[B]\}, \text{Army}[B, g].\text{Squadrons} > 0 \end{aligned}$$

Condition II:

$$\text{Army}[B, g].\text{FixSuppl} < 0))$$

Condition III: True

1.12: Segmentation fault when squadron leaves Terrain grid

Condition I: $\text{Active}(B, g)$

Condition II:

$$\begin{aligned} &(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop}) > 0 \wedge \\ &(X_{B, g, j}(\text{Mainloop}) < 0 \vee X_{B, g, j}(\text{Mainloop}) > \text{Params.XDelta} \times \text{MaxTerrain} \vee \\ &Y_{B, g, j}(\text{Mainloop}) < 0 \vee Y_{B, g, j}(\text{Mainloop}) > \text{Params.YDelta} \times \text{MaxTerrain})) \end{aligned}$$

Condition III: True

1.13: Weapon use functions misordered

Condition I:

$$\begin{aligned} &\exists B, g, e, \text{Active}(B, g) \wedge \text{Active}(\neg B, e) \wedge \\ &(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\ &(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Observe}(B, g, j, e, k, \text{Mainloop} - 1))) \end{aligned}$$

Condition II: True

Condition III:

$$\begin{aligned} &\{k' \mid (\exists j, \text{Observe}(B, g, j, e, k', \text{Mainloop}))\} \\ &\neq \{k'' \mid (\exists j, \text{Observe}(B, g, j, e, k'', \text{Mainloop} - 1))\} \wedge \\ &(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Duration}) > 0) \wedge \\ &(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k, \text{Duration}) > 0) \end{aligned}$$

1.14: Observation list reversed, causes error in firing

and

1.15: Unnecesary addition of one to target list subscript in arguments to SetLLCoords

and

1.16: Unnecesary adding of one to weapon subscript in arguments to SetLLCoords

and

1.26: Improper targeting due to misordered observation list

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge \\ &(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k, \text{Duration}) > 0 \wedge \\ &(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop}) > 0 \wedge \\ &\text{Observe}(B, g, j, e, k, \text{Mainloop} - 1))) \wedge \text{Params.NumWTypes} > 1 \end{aligned}$$

Condition II:

$$\begin{aligned} &(\exists k', 1 \leq k' \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k', \text{Mainloop} - 1) > 0 \wedge \\ &(\exists j, \text{Observe}(B, g, j, e, k', \text{Mainloop} - 1))) \wedge \\ &(x_{\neg B, e, k'}(\text{Mainloop}) \neq x_{\neg B, e, k}(\text{Mainloop}) \vee y_{\neg B, e, k'}(\text{Mainloop}) \neq y_{\neg B, e, k}(\text{Mainloop})) \end{aligned}$$

Condition III:

$$\begin{aligned} &| \{k \ni (\exists j, \text{Observe}(B, g, j, e, k, \text{Mainloop}))\} | > \\ &\min(\text{Army}[B, g].\text{WeapPriority}[e, 1], \text{NumWeapon}(B, g, 1, \text{Mainloop})) \wedge \\ &(\text{Army}[B, g].\text{Weapon}[1].\text{Damage} \neq \text{Army}[B, g].\text{Weapon}[2].\text{Damage} \vee \\ &\text{Army}[\neg B, e].\text{WeapSensativity}[1] \neq \text{Army}[\neg B, e].\text{WeapSensativity}[2]) \wedge \\ &(\nexists m, 1 \leq m \leq \text{NCmsgs}[\neg B], \\ &\text{Mimp}(\neg B, e, m, \text{Duration}) \wedge \neg \text{Mimp}(\neg B, e, m, \text{Mainloop})) \end{aligned}$$

1.17: Accepts Army.Squadrons=0 as valid data

Condition I:

$$(\exists B, B \in \{\text{true}, \text{false}\}, \text{NArmy}[B] > 0$$

Condition II: $\text{Army}[B, g].\text{Squadrons} = 0$)

Condition III: True

1.18: TerrMoveTM returns unstable value if battalion leaves terrain grid

Condition I: $\text{Active}(B, g)$

Condition II:

$$(X_{B,g}(\text{Mainloop}) < 0 \vee X_{B,g}(\text{Mainloop}) > \text{Params.XDelta} \times \text{MaxTerrain} \vee \\ Y_{B,g}(\text{Mainloop}) < 0 \vee Y_{B,g}(\text{Mainloop}) > \text{Params.YDelta} \times \text{MaxTerrain})$$

Condition III:

$$\text{Duration} > \text{Mainloop} \wedge \\ (\nexists i, 1 \leq i \leq \text{NCmsgs}[B], \text{Mimp}(B, g, i, \text{Duration}) \wedge \neg \text{Mimp}(B, g, i, \text{Mainloop} - 1))$$

1.19: NumCas not cleared by command message

Condition I:

$$\text{Active}(B, g) \wedge \\ (\exists i, 1 \leq i \leq \text{NCmsgs}[B], \text{Mimp}(B, g, i, \text{Mainloop}) \wedge \neg \text{Mimp}(B, g, i, \text{Mainloop} - 1))$$

Condition II:

$$\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Casualty}(B, g, j, \text{Mainloop})$$

Condition III: True

1.20: $NW > 0$ when $KF \leq 0$

Condition I:

$$\begin{aligned} & Active(B, g) \wedge NArmy[\neg B] > 0 \wedge Params.NumWTypes > 0 \wedge \\ & (\exists i, \quad 1 \leq i \leq Params.NumWTypes, \\ & \quad (Army[B, g].Weapon[i].NumWeapon > 0) \wedge \\ & \quad (Army[B, g].Weapon[i].UseLimit > 0) \wedge \\ & \quad (Army[B, g].Weapon[i].Range > 0) \wedge \\ & (\exists e, \quad 1 \leq e \leq NArmy[\neg B], Army[\neg B, e].Squadrons > 0 \wedge \\ & (\exists k, \quad 1 \leq k \leq Army[\neg B, e].Squadrons, \\ & (\exists j, \quad 1 \leq j \leq Army[B, g].Squadrons, \\ & \quad Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ & \quad Endurance(B, g, j, Mainloop) > 0 \wedge \\ & \quad Observe(B, g, j, e, k, Mainloop - 1) \wedge InRange(B, g, i, e, k, Mainloop) \end{aligned}$$

Condition II: $(Army[B, g].Weapon[i].FireRate \leq 0)$

Condition III:

$$\begin{aligned} & (Army[B, g].Weapon[i].Damage \neq 0) \wedge (Army[\neg B, e].WeaponSensitivity[i] > 0) \wedge \\ & (Duration > Mainloop) \wedge \\ & (\nexists r, 1 \leq r \leq NCmsgs[\neg B], \\ & Mimp(\neg B, e, r, Duration) \wedge \neg Mimp(\neg B, e, r, Mainloop - 1))) \end{aligned}$$

1.22: Report Message processed ahead of command message with equal priority, receipt time

Condition I:

$$\begin{aligned}
 &Active(B, g) \wedge Active(\neg B, e) \wedge Active(B, f) \wedge \\
 &(\exists i, 1 \leq i \leq NCmsgs[B], Mimp(B, g, i, Mainloop) \wedge \neg Mimp(B, g, i, Mainloop - 1) \wedge \\
 &Army[B, f].Report = g \wedge (\exists t, 1 \leq t \leq Duration, \\
 &(t = Mainloop - Army[B, g].ProcDelay - Army[B, g].MediaDelay \\
 &\quad - Army[B, f].SendRate - 1) \wedge \\
 &(\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, t) > 0 \wedge \\
 &\quad \exists j, 1 \leq j \leq Army[B, f].Squadrons, Observe(B, f, j, e, k, t)))
 \end{aligned}$$

Condition II: $Army[B, f].Priority = Cmsgs[B, i].Priority$

Condition III:

$$\begin{aligned}
 &\left(\sum_{m=1}^{NCmsgs[B]} \begin{cases} 1 & \text{if } Mimp(B, g, m, Mainloop) \wedge \neg Mimp(B, g, m, Mainloop - 1) \\ 0 & \text{otherwise} \end{cases} \right) \\
 &\geq NumProcess(B, g, Mainloop)
 \end{aligned}$$

1.23: Invalid width, height when squadron leaves grid

Condition I: $Active(B, g)$

Condition II:

$$\begin{aligned}
 &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\
 &(X_{B,g,j}(Mainloop) < 0 \vee X_{B,g,j}(Mainloop) > Params.XDelta \times MaxTerrain \vee \\
 &Y_{B,g,j}(Mainloop) < 0 \vee Y_{B,g,j}(Mainloop) > Params.YDelta \times MaxTerrain))
 \end{aligned}$$

Condition III:

$$(\exists i, 1 \leq i \leq NCmsgs[B], Mimp(B, g, i, Duration) \wedge \neg Mimp(B, g, i, Mainloop - 1))$$

1.25: Observations and Weapon coordinates cleared by command messages

Condition I:

$$Active(B, g) \wedge (\exists i, 1 \leq i \leq NCmsgs[B], Mimp(B, g, i, Mainloop) \wedge \neg Mimp(B, g, i, Mainloop - 1))$$

Condition II:

$$\begin{aligned} &Active(\neg B, e) \wedge \\ &(\exists i, 1 \leq i \leq Params.NumWTypes, \\ &\quad (NumWeapon(B, g, i, Mainloop) > 0 \wedge \\ &\quad (Army[B, g].Weapon[i].FireRate > 0) \wedge \\ &\quad (Army[B, g].Weapon[i].UseLimit > 0) \wedge \\ &\quad (Army[B, g].Weapon[i].Range > 0) \wedge \\ &(\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, \\ &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, \\ &\quad Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &\quad Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\quad Observe(B, g, j, e, k, Mainloop - 1) \wedge InRange(B, g, i, e, k, Mainloop - 1)) \end{aligned}$$

Condition III:

$$\begin{aligned} &(Army[B, g].Weapon[i].Damage \neq 0) \wedge (Army[\neg B, e].WeaponSensitivity[i] > 0) \wedge \\ &(Duration > Mainloop + 1) \wedge (\neg Casualty(\neg B, e, k, Mainloop)) \wedge \\ &0.5 > \frac{Endurance(\neg B, e, k, Mainloop) - Damage(\neg B, e, k, Mainloop) + Damage(\neg B, e, k, Mainloop - 1)}{Army[\neg B, e].Endurance[k]} \wedge \\ &(\nexists r, 1 \leq r \leq NCmsgs[\neg B], \\ &Mimp(\neg B, e, r, Duration) \wedge \neg Mimp(\neg B, e, r, Mainloop - 1))) \end{aligned}$$

1.27: Enemy instead of current position in observation jamming

Condition I:

$$\begin{aligned}
 &Active(\neg B, e) \wedge Active(B, g) \wedge \\
 &(\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, \\
 &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, \\
 &\quad Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\
 &\quad Endurance(B, g, j, Mainloop) > 0 \wedge BigEnough(B, g, j, e, k, t) \wedge Clear(B, g, j, e, k, t)
 \end{aligned}$$

Condition II:

$$\begin{aligned}
 &Params.SampleRate > 2 \wedge \\
 &(x_{\neg B, e}(Mainloop) \neq x_{B, g}(Mainloop) \vee \\
 &y_{\neg B, e}(Mainloop) \neq y_{B, g}(Mainloop)) \wedge \\
 &x_{gj} = x_{B, g, j}(t - 1) \wedge y_{gj} = y_{B, g, j}(t - 1) \wedge \\
 &x_{ek} = x_{\neg B, e, k}(t - 1) \wedge y_{ek} = y_{\neg B, e, k}(t - 1) \wedge \\
 &\left(\left(\frac{BI(a', c', x_{ek}, y_{ek}) - Army[\neg B, e].SquadIntensity[k]}{BI(a', c', x_{ek}, y_{ek})} - \right. \right. \\
 &Params.SampleRate \\
 &\quad \sum_{n=1} ((WO(x_{ek}, y_{ek}, Mainloop) \times Army[B, g].VWEffect) + \\
 &\quad \sum_{e'=1}^{NArmy[\neg B]} \left\{ \begin{array}{ll} 0 & \text{if } \sqrt{(x_{\neg B, e'}(Mainloop - 1) - x_{ek})^2 + (y_{\neg B, e'}(Mainloop - 1) - y_{ek})^2} > Army[\neg B, e'].ObsJamRadius \\ \frac{\sqrt{(x_{\neg B, e'}(Mainloop - 1) - x_{ek})^2 + (y_{\neg B, e'}(Mainloop - 1) - y_{ek})^2}}{Army[\neg B, e'].ObsJamRadius} & \times Army[\neg B, e'].ObsJamEff \text{ otherwise} \end{array} \right. \\
 &\left. \right) < Army[B, g].ObsMinContrast[j])
 \end{aligned}$$

Condition III: True

1.28: Allocated fixing exceeds NumFixers×FixRate

Condition I:

$$Active(B, g) \wedge (\exists j, 1 \leq j \leq Army[B, g].Squadrons, Casualty(B, g, j, Mainloop))$$

Condition II:

$$\begin{aligned}
 &(Endurance(B, g, j, Mainloop) - Army[B, g].Endurance[j]) > \\
 &(Army[B, g].FixRate \times NumFix(B, g, Mainloop))
 \end{aligned}$$

Condition III:

$$\begin{aligned}
 &(Endurance(B, g, j, Mainloop) + Army[B, g].FixRate \times NumFix(B, g, Mainloop)) \\
 &< \frac{Army[B, g].Endurance[j]}{2} \wedge \\
 &(\nexists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Duration) \wedge \neg Mimp(B, g, m, Mainloop))
 \end{aligned}$$

Failure Regions in Version 2

2.1: No check if report message destination is existing battalion

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge \\ &(\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, \\ &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, \\ &(\exists t, 1 \leq t \leq Mainloop, Observe(B, g, j, e, k, t)))) \end{aligned}$$

Condition II: $0 > Army[B, g].Report \vee NArmy[B] < Army[B, g].Report$

Condition III: True

2.2: No check if command message destination is existing battalion

Condition I:

$$\begin{aligned} &Duration > 0 \wedge \exists t, 1 \leq t \leq Duration, \\ &\exists B, B \in \{true, false\}, NArmy[B] > 0 \end{aligned}$$

Condition II:

$$\begin{aligned} &\exists m, 1 \leq m \leq NCmsgs[B], Cmsgs[B, m].Time = t \wedge \\ &Cmsgs[B, m].Army = B \wedge (Cmsgs[B, m].Dest < 0 \vee Cmsgs[B, m].Dest > NArmy[B]) \end{aligned}$$

Condition III: True

2.3: Message not queued for processing in next dt

Condition I:

$$Active(B, g) \wedge (\exists m, 1 \leq m \leq NCmsgs[B], RecT(B, g, m) = Mainloop)$$

Condition II:

$$\begin{aligned} &CmdSum(B, g, m, Mainloop) + ReptSum(B, g, m, Mainloop) \\ &= NumProcess(B, g, Mainloop - 1) \end{aligned}$$

Condition III: True

2.4: Improper count of available receivers

Condition I:

$$Active(B, g) \wedge \exists j, 1 \leq j \leq Army[B, g].Squadrons, Casualty(B, g, j, Mainloop)$$

Condition II:

$$NumRec(B, g, Mainloop) \neq NumRec(B, g, Mainloop - 1)$$

Condition III:

$$\exists m, 1 \leq m \leq NCmsgs[B], Cmsgs[B, g].Dest = g \wedge RecT(B, g, m) = Mainloop$$

2.5: Incomplete recalculation when command implemented

Condition I:

$$Active(B, g) \wedge (\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Mainloop))$$

Condition II:

$$\begin{aligned} & (\exists e, 1 \leq e \leq NArmy[\neg B], Army[\neg B, e].Squadrons > 0 \wedge \\ & \exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ & \exists j, 1 \leq j \leq Army[B, g].Squadrons, \\ & Endurance(B, g, j, Mainloop) > 0 \wedge Observe(B, g, j, e, k, Mainloop - 1)) \\ & \vee Army[B, g].NumReceive \neq Cmsgs[B, m].msg.NumReceive \end{aligned}$$

Condition III:

$$\begin{aligned} & (\exists m', 1 \leq m' \leq NCmsgs[B], Mimp(B, g, m, Duration) \wedge \neg Mimp(B, g, m, Mainloop)) \\ & \vee (\exists i, 1 \leq i \leq Params.NumWTypes, InRange(B, g, i, e, k, Mainloop)) \end{aligned}$$

2.6: Program fails when squadron exceeds Terrain boundaries and

2.31: Use of borders to initialize w,h calculation causes problems

Condition I: (Duration > 0)

Condition II:

$$\begin{aligned} &\exists B, g, \text{Active}(B, g) \wedge \\ &\quad (X_{B,g}(\text{Mainloop}) \geq \text{Params.XDelta} \times \text{MaxTerrain} \vee \\ &\quad Y_{B,g}(\text{Mainloop}) \geq \text{Params.YDelta} \times \text{MaxTerrain}) \end{aligned}$$

Condition III: True

2.7: Wrong points checked in subtended angle calculation

Condition I:

$$\begin{aligned} &\text{Active}(B, g) \wedge \text{Active}(\neg B, e) \wedge \\ &\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop}) > 0 \wedge \\ &\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k, \text{Mainloop}) > 0 \end{aligned}$$

Condition II:

$$\begin{aligned} &(X_{B,g,j}(\text{Mainloop} - 1) > X_{\neg B,e,k}(\text{Mainloop} - 1) + \frac{\text{Army}[\neg B,e].\text{SquadWidth}}{2} \wedge \\ &Y_{B,g,j}(\text{Mainloop} - 1) \leq Y_{\neg B,e,k}(\text{Mainloop} - 1) + \frac{\text{Army}[\neg B,e].\text{SquadLength}}{2} \end{aligned}$$

Condition III:

$$\begin{aligned} &\text{Army}[\neg B, e].\text{SquadWidth} > 0 \wedge \neg \text{Observe}(B, g, j, e, k, \text{Mainloop}) \wedge \\ &\text{Clear}(B, g, j, e, k, \text{Mainloop}) \wedge \text{Obvious}(B, g, j, e, k, \text{Mainloop}) \wedge \\ &(\forall t, 1 \leq t \leq \text{Duration}, \\ &\quad \neg \exists j', 1 \leq j' \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j', t) > 0 \wedge \\ &\quad \exists k', 1 \leq k' \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k', t) > 0 \wedge \\ &\quad \text{Observe}(B, g, j', e, k', t)) \end{aligned}$$

2.8: Calculates the wrong angle if Observer, two corners are colinear

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge \\ &\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop}) > 0 \wedge \\ &\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k, \text{Mainloop}) > 0 \end{aligned}$$

Condition II:

$$\begin{aligned} &((Y_{B,g,j}(\text{Mainloop} - 1) = Y_{\neg B,e,k}(\text{Mainloop} - 1) + \frac{\text{Army}[\neg B,e].\text{SquadLength}}{2}) \vee \\ &(Y_{B,g,j}(\text{Mainloop} - 1) = Y_{\neg B,e,k}(\text{Mainloop} - 1) - \frac{\text{Army}[\neg B,e].\text{SquadLength}}{2})) \wedge \\ &|X_{B,g,j}(\text{Mainloop} - 1) - X_{\neg B,e,k}(\text{Mainloop} - 1)| < \frac{\text{Army}[\neg B,e].\text{SquadWidth}}{2} \end{aligned}$$

Condition III:

$$\begin{aligned} &\text{Army}[\neg B, e].\text{SquadWidth} > 0 \wedge \neg \text{Observe}(B, g, j, e, k, \text{Mainloop}) \wedge \\ &\text{Clear}(B, g, j, e, k, \text{Mainloop}) \wedge \text{Obvious}(B, g, j, e, k, \text{Mainloop}) \wedge \\ &(\forall t, 1 \leq t \leq \text{Duration}, \\ &\quad \exists j', 1 \leq j' \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j', t) > 0 \wedge \\ &\quad \exists k', 1 \leq k' \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k', t) > 0 \wedge \\ &\quad \text{Observe}(B, g, j', e, k', t)) \end{aligned}$$

2.10: No check if Params.XDelta = 0

Condition I: True

Condition II: Params.XDelta = 0

Condition III: True

2.11: No check if Params.YDelta = 0

Condition I: True

Condition II: Params.YDelta = 0

Condition III: True

2.12: No check if Params.SampleRate < 2

Condition I: True

Condition II: Params.SampleRate < 2

Condition III: True

2.13: Infinite velocity if $E0 = 0$

Condition I:

$$\text{Duration} > 0 \wedge \exists B, B \in \{\text{true}, \text{false}\}, \text{NArmy}[B] > 0 \wedge \\ \exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B, g].\text{Squadrons} > 0$$

Condition II: $\forall j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Army}[B, g].\text{Endurance}[j] > 0$

Condition III:

$$(\forall i, 1 \leq i \leq \text{NCmsgs}[B], \text{Mimp}(B, g, i, \text{Duration}) \wedge \neg \text{Mimp}(B, g, i, \text{Mainloop} - 1))$$

2.14: No check if $\text{Army.NumFixers} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$(\exists B, B \in \{1 \dots \text{NArmy}[\text{true}]\}, \\ \text{Army}[\text{true}, B].\text{NumFixers} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ (\exists B, B \in \{1 \dots \text{NArmy}[\text{false}]\}, \\ \text{Army}[\text{false}, B].\text{NumFixers} > \text{Army}[\text{false}, B].\text{Squadrons})$$

Condition III: True

2.15: No check if $\text{Army.NumJammers} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$(\exists B, B \in \{1 \dots \text{NArmy}[\text{true}]\}, \\ \text{Army}[\text{true}, B].\text{NumJammers} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ (\exists B, B \in \{1 \dots \text{NArmy}[\text{false}]\}, \\ \text{Army}[\text{false}, B].\text{NumJammers} > \text{Army}[\text{false}, B].\text{Squadrons})$$

Condition III: True

2.16: No check if $\text{Army.NumProcess} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$(\exists B, B \in \{1 \dots \text{NArmy}[\text{true}]\}, \\ \text{Army}[\text{true}, B].\text{NumProcess} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ (\exists B, B \in \{1 \dots \text{NArmy}[\text{false}]\}, \\ \text{Army}[\text{false}, B].\text{NumProcess} > \text{Army}[\text{false}, B].\text{Squadrons})$$

Condition III: True

2.17: No check if $\text{Army.NumReceive} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumReceive} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumReceive} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

2.18: No check if $\text{Army.NumSend} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumSend} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumSend} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

2.19: No check if $\text{Cmsgs.msg.NumFixers} > \text{Cmsgs.msg.Squadrons}$

Condition I:

$$\begin{aligned} &\exists B, \quad B \in \{\text{true}, \text{false}\}, \\ &\quad (\exists f, 1 \leq f \leq N\text{Army}[B], \\ &\quad \quad (\exists m, m \in \{1 \dots N\text{Cmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{Msg.NumFixers} > \text{Cmsgs}[B, m].\text{Msg.Squadrons}$$

Condition III: True

2.20: No check if $\text{Cmsgs.msg.NumJammers} > \text{Cmsgs.msg.Squadrons}$

Condition I:

$$\begin{aligned} &\exists B, \quad B \in \{\text{true}, \text{false}\}, \\ &\quad (\exists f, 1 \leq f \leq N\text{Army}[B], \\ &\quad \quad (\exists m, m \in \{1 \dots N\text{Cmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg.NumJammers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$$

Condition III: True

2.21: No check if Cmsgs.msg.NumProcess > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad & B \in \{\text{true}, \text{false}\}, \\ & (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ & \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumProcess} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

2.22: No check if Cmsgs.msg.NumReceive > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad & B \in \{\text{true}, \text{false}\}, \\ & (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ & \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumReceive} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

2.23: No check if Cmsgs.msg.NumSend > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad & B \in \{\text{true}, \text{false}\}, \\ & (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ & \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumSend} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

2.25: Multiple Reports processed in queue order

Condition I:

$$\begin{aligned}
 &Active(\neg B, e) \wedge Active(B, g) \wedge Active(B, f) \wedge Active(B, f') \wedge f \neq f' \wedge \\
 &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, (Endurance(\neg B, e, Mainloop) > 0) \wedge \\
 &(\exists t, t = Mainloop - Army[B, f].SendRate - Army[B, g].MediaDelay - \\
 &\quad \frac{Army[B, g].RecRate}{Army[B, g].NumReceive} - Army[B, g].ProcDelay \\
 &\exists j, 1 \leq j \leq Army[B, f].Squadrons, Endurance(B, f, j, t) > 0 \wedge Observe(B, f, j, e, k, t)) \wedge \\
 &(\exists t', t' = Mainloop - RepT(B, f', g) - Army[B, g].ProcDelay \\
 &\quad - \frac{Army[B, g].RecRate}{NumRec(B, g, Mainloop - Army[B, g].ProcDelay)} \\
 &\exists j', 1 \leq j' \leq Army[B, f'].Squadrons, Endurance(B, f', j', t') > 0 \\
 &\wedge Observe(B, f', j', e, k, t'))
 \end{aligned}$$

Condition II:

$$\begin{aligned}
 &Army[B, f].Priority > Army[B, f'].Priority \wedge \\
 &Army[B, f].SendRate > Army[B, f'].SendRate
 \end{aligned}$$

Condition III:

$$\begin{aligned}
 &(\exists i, 1 \leq i \leq Params.NumWTypes, InRange(B, g, i, e, k, Mainloop + 1)) \wedge \\
 &(\forall t, 1 \leq t \leq Duration, \\
 &\quad \exists j', 1 \leq j' \leq Army[B, g].Squadrons, Endurance(B, g, j', t) > 0 \wedge \\
 &\quad \exists k', 1 \leq k' \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k', t) > 0 \wedge \\
 &\quad Observe(B, g, j', e, k', t))
 \end{aligned}$$

2.26: gold observes when version does not

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$SomeObserve(\neg B, e, g, 2) \wedge (\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, 1))$$

Condition II: True

2.30: Alt poorly defined when battalion leaves terrain grid

Condition I: $(Duration > 0)$

Condition II:

$$\begin{aligned}
 &\exists B, g, Active(B, g) \wedge \\
 &\quad (X_{B, g}(Mainloop) \leq 0 \vee Y_{B, g}(Mainloop) \leq 0)
 \end{aligned}$$

Condition III: True

Failure Regions in Version 3

3.1: Improper count on number of busy processors in procedure ReceiveMessages

Condition I:

$$\begin{aligned}
 & (\exists B, (\exists f, Active(B, f) \wedge \\
 & \quad (Army[B, f].NumReceive > 0) \wedge \\
 & \quad (NCmsgs[B] > 0) \wedge \\
 & \quad (\exists i, 1 \leq i \leq NCmsgs[B], PTR.CMessage = i))) \\
 & \wedge (PTR \neq nil) \wedge (PTR.DestArmy = B) \wedge (PTR.DestBatt = f)
 \end{aligned}$$

Condition II: $(PTR.Processed = recd) \wedge (PTR.TimeRecd = Mainloop)$

Condition III:

$$\begin{aligned}
 & \left(\sum_{M=HeadQueue}^{M.next=null} \begin{cases} 1 & \text{if } (M.DestArmy = B) \wedge (M.DestBatt = f) \wedge \\ & (M.Processed = recd) \wedge (M.TimeRecd \geq Mainloop) \end{cases} \right) \\
 & \geq Army[B, f].NumProcess \wedge \\
 & \left(\sum_{M=HeadQueue}^{M.next=nil} \begin{cases} 1 & \text{if } (M.DestArmy = B) \wedge (M.DestBatt = f) \wedge \\ & (M.Processed = recd) \wedge (M.TimeRecd > Mainloop) \end{cases} \right) \\
 & < Army[B, f].NumProcess \wedge \\
 & (\exists M, M \in \{HeadQueue, \dots, nil\}, \\
 & (M.DestArmy = B) \wedge (M.DestBatt = f) \wedge \\
 & (M.Processed = arrvd) \wedge (M.TimeSent \leq Duration)) \vee \\
 & (\exists M, M \in Cmsgs[B], (M.Dest = f) \wedge (M.Time > Mainloop) \wedge \\
 & (M.Time < Duration \wedge (M.mesg \neq Cmsgs[B][PTR.CMessage])))
 \end{aligned}$$

3.2: Violation of queue structure when messages of equal priority are ready for processing

Condition I:

$$\begin{aligned} &Active(B, f) \wedge (Army[B, f].NumReceive > 0) \wedge \\ &(NCmsgs[B] > 0) \wedge (\exists i, 1 \leq i \leq NCmsgs[B], Rec^{\wedge}.CMessage = i) \wedge \\ &(HeadQueue \neq nil) \end{aligned}$$

$$\begin{aligned} &(\exists M, M \in \{HeadQueue \dots nil\}, \\ &(M^{\wedge}.CMessage \neq Rec^{\wedge}.CMessage) \wedge \\ &(M^{\wedge}.DestArmy = B) \wedge (M^{\wedge}.DestBatt = f)) \end{aligned}$$

Condition II: $(\exists place, place \in \{HeadQueue \dots nil\}, place^{\wedge}.priority < Rec^{\wedge}.priority)$

Condition III: True

3.3: Message implemented in destroyed battalions in procedure FollowCommandMessages

Condition I:

$$\begin{aligned} &(\text{Duration} > 0) \wedge (\text{Mainloop} \in \{0 \dots \text{Duration}\}) \\ &\wedge (((B = \text{True}) \wedge (NArmy[B] > 0) \wedge (f \in \{1 \dots NArmy[B]\}) \wedge \\ &\quad (Army[B, f].Squadrons > 0) \wedge \\ &\quad (Army[B, f].NumReceive > 0) \wedge \\ &\quad (\exists i, 1 \leq i \leq Army[B, f].Squadrons, \\ &\quad \quad Endurance(B, f, i, \text{Mainloop}) > 0) \wedge \\ &\quad (NCmsgs[B] > 0) \wedge \\ &\quad (\exists i, 1 \leq i \leq NCmsgs[B], Match^{\wedge}.CMessage = i)) \vee \\ &\quad ((B = \text{False}) \wedge (NArmy[B] > 0) \wedge (f \in \{1 \dots NArmy[B]\}) \wedge \\ &\quad (Army[B, f].Squadrons > 0) \wedge \\ &\quad (Army[B, f].NumReceive > 0) \wedge \\ &\quad (\exists i, 1 \leq i \leq Army[B, f].Squadrons, \\ &\quad \quad Endurance(B, f, i, \text{Mainloop}) > 0) \wedge \\ &\quad (NCmsgs[B] > 0) \wedge \\ &\quad (\exists i, 1 \leq i \leq NCmsgs[B], Match^{\wedge}.CMessage = i))) \\ &\wedge \left(K = \sum_{s=1}^{Army[B, f].Squadrons} \begin{cases} 1 & \text{if } Endurance(B, f, s, \text{Mainloop}) \leq 0 \\ 0 & \text{otherwise} \end{cases} \right) \\ &\wedge Match \neq NIL \end{aligned}$$

Condition II:

$$Army[B, f].Squadrons - K \leq 0$$

Condition III: True

3.4: Initial Endurance ≤ 0 reported erroneous in command messages

Condition I:

$$\exists B, \quad B \in \{\text{true}, \text{false}\}, \\ (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration})))$$

Condition II:

$$\exists j, 1 \leq j \leq \text{Cmsgs}[B, m].\text{Msg.Squadrons}, \text{Cmsgs}[B, m].\text{Msg.Endurance}[s] \leq 0$$

Condition III: True

3.5: Initial velocity counted incorrect if Endurance ≤ 0

Condition I:

$$(\text{ArmyNum} \in \{\text{true}, \text{false}\}) \wedge (\text{Batt} \in \{1 \dots \text{NArmy}[\text{ArmyNum}]\}) \wedge \\ (\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons} > 0)$$

Condition II:

$$(\exists s, s \in \{1 \dots \text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons}\}, \\ \text{Army}[\text{ArmyNum}, \text{Batt}].\text{Endurance}[s] \leq 0) \wedge \\ (\exists i, i \in \{1 \dots \text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons}\}, \text{Army}[\text{ArmyNum}, \text{Batt}].\text{V0}[i] \neq 0)$$

Condition III:

$$(\nexists s', s' \in \{1 \dots \text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons}\}, \\ (\text{Army}[\text{ArmyNum}, \text{Batt}].\text{V0}[s'] < \\ \text{Army}[\text{ArmyNum}, \text{Batt}].\text{V0}[s]) \wedge \\ (\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Endurance}[s'] \leq 0)) \\ ((\text{Duration} = 0) \vee \\ (\nexists m, m \in \{1 \dots \text{NCmsgs}[\text{ArmyNum}]\}, \\ \text{Mimp}(\text{ArmyNum}, \text{Batt}, m, \text{Duration})))$$

3.6: Array range violations in BatPosition lead to setting of wrong battalion's squad positions

Condition I: $\exists B, \exists g, Active(B, g)$

Condition II:

$$Endurance(B, g, Army[B, g].Squadrons, Mainloop) \leq 0$$

Condition III: True

3.7: KU equations not supported

and

3.8: dNK equations not supported

Condition I:

$$(\exists B, (\exists g, Active(B, g) \wedge \\ (Params.NumWTypes > 0)))$$

$$(\exists i, 1 \leq i \leq Params.NumWTypes, \\ (Army[B, g].Weapon[i].NumWeapon > 0) \wedge \\ (Army[B, g].Weapon[i].FireRate > 0) \wedge \\ (Army[B, g].Weapon[i].UseLimit > 0) \wedge \\ (Army[B, g].Weapon[i].Range > 0) \wedge$$

$$(\exists e, 1 \leq e \leq NArmy[\neg B], \\ (\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, \\ (\exists j, 1 \leq j \leq Army[B, g].Squadrons, \\ Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ Endurance(B, g, j, Mainloop) > 0 \wedge \\ Observe(B, g, j, e, k, Mainloop) \wedge InRange(B, g, i, e, k, Mainloop) \\) \quad) \quad))$$

Condition II: True

Condition III:

$$(\nexists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Duration) \wedge \\ \neg Mimp(B, g, m, Mainloop))$$

3.9: Wrong Sx,Sy used in calculation of K

Condition I:

$$\begin{aligned}
 &Active(B, g) \wedge Active(\neg B, e) \wedge \\
 &(\exists i, 1 \leq i \leq Params.NumWTypes, \\
 &\quad (Army[B, g].Weapon[i].NumWeapon > 0) \wedge \\
 &\quad (Army[B, g].Weapon[i].FireRate > 0) \wedge \\
 &\quad (Army[B, g].Weapon[i].UseLimit > 0) \wedge \\
 &\quad (Army[B, g].Weapon[i].Range > 0) \wedge \\
 &(\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, \\
 &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, \\
 &\quad Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\
 &\quad Endurance(B, g, j, Mainloop) > 0 \wedge \\
 &\quad Observe(B, g, j, e, k, Mainloop) \wedge InRange(B, g, i, e, k, Mainloop) \wedge \\
 &\quad xek = x_{\neg B, e, k}(Mainloop - 1) \wedge yek = y_{\neg B, e, k}(Mainloop - 1) \\
 &))
 \end{aligned}$$

Condition II: $(Army[B, g].X \neq xek) \wedge (Army[B, g].Y \neq yek)$

Condition III:

$$\begin{aligned}
 &(Duration > Mainloop + 1) \wedge Casualty(\neg B, e, k, Mainloop + 1) \wedge \\
 &0.5 < \frac{Endurance(\neg B, e, k, Mainloop) + Damage(\neg B, e, k, Mainloop) - \\
 &\quad Damage(\neg B, e, k, Mainloop - 1)}{Army[\neg B, e].Endurance[k]}
 \end{aligned}$$

$$\wedge (\nexists m, 1 \leq m \leq NCmsgs[\neg B], Mimp(\neg B, e, m, Duration) \wedge \neg Mimp(\neg B, e, m, Mainloop))$$

3.10: Duration=0 considered erroneous

Condition I: True

Condition II: $Duration = 0$

Condition III: True

3.11: $M > \text{MaxTerrain}$ instead if $M \geq \text{MaxTerrain}$ in findA
and

3.20: $N > \text{MaxTerrain}$ instead if $N \geq \text{MaxTerrain}$ in findA

Condition I: $(\text{Duration} > 0)$

Condition II:

$$\begin{aligned} & \exists B, g, \text{Active}(B, g) \wedge \\ & X_{B,g}(\text{Mainloop}) = \text{Params.XDelta} \times \text{MaxTerrain [for 3.11]} \vee \\ & Y_{B,g}(\text{Mainloop}) = \text{Params.YDelta} \times \text{MaxTerrain [for 3.20]} \end{aligned}$$

Condition III: True

3.12: TM undefined when $\text{Dist} = 0$

Condition I: $\text{Active}(B, g)$

Condition II: $V(B, g, \text{Mainloop}) = 0$

Condition III:

$$\begin{aligned} & (\text{Duration} > \text{Mainloop}) \wedge \\ & (x_{B,g}(\text{Mainloop}) \neq x_{B,g}(\text{Mainloop} - 1) \vee \\ & y_{B,g}(\text{Mainloop}) \neq y_{B,g}(\text{Mainloop} - 1)) \wedge \\ & (\nexists m, 1 \leq m \leq \text{NCmsgs}[B], \text{Mimp}(B, g, m, \text{Duration}) \wedge \neg \text{Mimp}(B, g, m, \text{Mainloop})) \end{aligned}$$

3.13: Observation from side uses wrong points in angle calculation

Condition I:

$$\begin{aligned} & \text{Active}(B, g) \wedge \text{Active}(\neg B, e) \wedge \\ & (\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, (\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \\ & (x_{B,g,j}(\text{Mainloop} - 1) > x_{\neg B,e,k}(\text{Mainloop} - 1) \wedge \\ & y_{B,g,j}(\text{Mainloop} - 1) = y_{\neg B,e,k}(\text{Mainloop} - 1)) \vee \\ & (x_{B,g,j}(\text{Mainloop} - 1) < x_{\neg B,e,k}(\text{Mainloop} - 1) \wedge \\ & y_{B,g,j}(\text{Mainloop} - 1) = y_{\neg B,e,k}(\text{Mainloop} - 1)) \vee \\ & (x_{B,g,j}(\text{Mainloop} - 1) = x_{\neg B,e,k}(\text{Mainloop} - 1)) \end{aligned}$$

Condition II: $\text{Army}[\neg B, e].\text{SquadLength} > 0 \vee \text{Army}[\neg B, e].\text{SquadWidth} > 0$

Condition III:

$$\text{Clear}(B, g, j, e, k, \text{Mainloop}) \wedge \text{Obvious}(B, g, j, e, k, \text{Mainloop}))$$

3.15: Assumes that velocity never exceeds 99999

Condition I: $\text{Duration} > 0$

Condition II:

$$\begin{aligned} &\exists B, g, B \in \{\text{true}, \text{false}\}, 1 \leq g \leq \text{NArmy}[B], \\ &\quad (\exists s, 1 \leq s \leq \text{Army}[B, g].\text{Squadrons}, \\ &\quad \quad \text{Endurance}(B, g, s, \text{Mainloop}) > 0 \wedge \text{Army}[B, g].\text{V0}[s] > 99999) \vee \\ &\quad (\exists m, 1 \leq m \leq \text{NCmsgs}[B], \text{Mimp}(B, g, m, \text{Duration}) \wedge \\ &\quad (\exists s, 1 \leq s \leq \text{Cmsgs}[B, m].\text{Msg.Squadrons}, \\ &\quad \quad \text{Cmsgs}[B, m].\text{Msg.Endurance}[s] > 0 \wedge \text{Cmsgs}[B][m].\text{Msg.V0}[s] > 99999)) \end{aligned}$$

Condition III: True

3.16: SegViolation in FindA when battalion leaves defined terrain

Condition I: $(\text{Duration} > 0)$

Condition II:

$$\begin{aligned} &\exists B, g, \text{Active}(B, g) \wedge \\ &\quad (X_{B,g}(\text{Mainloop}) \geq \text{Params.XDelta} \times \text{MaxTerrain} \vee \\ &\quad Y_{B,g}(\text{Mainloop}) \geq \text{Params.YDelta} \times \text{MaxTerrain} \vee \\ &\quad X_{B,g}(\text{Mainloop}) \leq 0 \vee Y_{B,g}(\text{Mainloop}) \leq 0) \end{aligned}$$

Condition III: True

3.17: Result variables not set if $\text{Duration} < 0$

Condition I: True

Condition II: $(\text{Duration} < 0) \wedge ((\text{NArmy}[\text{true}] > 0) \vee (\text{NArmy}[\text{false}] > 0))$

Condition III: True

3.18: N undefined in WeaponsSighting at first occurrence

and

3.19: M undefined in WeaponsSighting at first occurrence

Condition I: $(\exists B, (\exists g, Active(B, g)))$

Condition II: True

Condition III:

$(\exists i, 1 \leq i \leq Params.NumWTypes,$
 $(Army[B, g].Weapon[i].NumWeapon > 0) \wedge (Army[B, g].Weapon[i].FireRate > 0) \wedge$
 $(Army[B, g].Weapon[i].UseLimit > 0) \wedge (Army[B, g].Weapon[i].Range > 0) \wedge$

$(\exists e, 1 \leq e \leq NArmy[\neg B],$
 $(\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons,$
 $(\exists j, 1 \leq j \leq Army[B, g].Squadrons,$
 $Endurance(\neg B, e, k, Mainloop) > 0 \wedge Endurance(B, g, j, Mainloop) > 0 \wedge$
 $Observe(B, g, j, e, k, Mainloop) \wedge InRange(B, g, i, e, k, Mainloop))))))$

3.21: Does not reject NArmy<0

Condition I: $(Duration \geq 0)$

Condition II: $(NArmy[true] < 0) \vee (NArmy[false] < 0)$

Condition III: True

3.22: Restoration allotted when FS<0

Condition I: $Active(B, g) \wedge (\exists j, 1 \leq j \leq Army[B, g].Squadrons, Casualty(B, g, j, Mainloop))$

Condition II: $Suppl(B, g, Mainloop) < 0$

Condition III: True

3.23: Messages lost if NumProcess goes transiently to 0

Condition I:

$$\begin{aligned} &Active(B, g) \wedge \\ &(\exists m, 1 \leq m \leq NCmsgs[B], ((Cmsgs[B, m].Time + Army[B, g].MediaDelay \\ &+ Army[B, g].ProcDelay) = Mainloop) \wedge \\ &(Cmsgs[B, m].Dest = g)) \end{aligned}$$

Condition II:

$$0 = NumProcess(B, g, Mainloop)$$

Condition III:

$$0 < NumProcess(B, g, Mainloop + 1)$$

$$(\exists m', 1 \leq m' \leq NCmsgs[B], (\neg Mimp(B, g, m', Mainloop)) \wedge Mimp(B, g, m', Duration))$$

3.24: Positions not initialized when Duration=0

Condition I:

$$\begin{aligned} &(ArmyNum \in \{true, false\}) \wedge (Batt \in \{1 \dots NArmy[ArmyNum]\}) \wedge \\ &(Army[ArmyNum, Batt].Squadrons > 0) \end{aligned}$$

Condition II: True

Condition III: (Duration = 0)

3.25: Positions centered on current, not previous, battalion x,y

Condition I: $Active(B, g)$

Condition II:

$$\begin{aligned} &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, \\ &Army[B, g].V0[j] > 0 \wedge Endurance(B, g, j, Mainloop) > 0) \end{aligned}$$

Condition III: True

3.26: Initially destroyed squadrons not in “Killed”

Condition I:

$$(\text{ArmyNum} \in \{\text{true}, \text{false}\}) \wedge (\text{Batt} \in \{1 \dots \text{NArmy}[\text{ArmyNum}]\}) \wedge (\text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons} > 0)$$

Condition II:

$$(\exists s, s \in \{1 \dots \text{Army}[\text{ArmyNum}, \text{Batt}].\text{Squadrons}\}, \text{Army}[\text{ArmyNum}, \text{Batt}].\text{Endurance}[s] \leq 0)$$

Condition III:

$$((\text{Duration} = 0) \vee (\nexists m, m \in \{1 \dots \text{NCmsgs}[\text{ArmyNum}]\}, \text{Mimp}(\text{ArmyNum}, \text{Batt}, m, \text{Duration})))$$

3.28: FindA returns poorly defined value if $X < 0$

Condition I:

$$\text{Active}(B, g)$$

Condition II:

$$x_{B,g}(\text{Mainloop}) < 0 \vee (\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, x_{B,g,j}(\text{Mainloop}) < 0)$$

Condition III:

$$\nexists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, g, m, \text{Duration})$$

3.32: Does not reject $\text{Army.Squadrons} = 0$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$(\exists B, B \in \{1 \dots \text{NArmy}[\text{true}]\}, \text{Army}[\text{true}, B].\text{Squadrons} = 0) \vee (\exists B, B \in \{1 \dots \text{NArmy}[\text{false}]\}, \text{Army}[\text{false}, B].\text{Squadrons} = 0)$$

Condition III: True

3.33: Does not reject $\text{Army.NumFixers} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumFixers} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumFixers} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

3.34: Does not reject $\text{Army.NumJammers} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumJammers} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumJammers} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

3.35: Does not reject $\text{Army.NumProcess} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumProcess} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumProcess} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

3.36: Does not reject $\text{Army.NumReceive} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumReceive} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumReceive} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

3.37: Does not reject $\text{Army.NumSend} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots \text{NArmy}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumSend} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots \text{NArmy}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumSend} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

3.38: Does not reject $\text{Cmsgs.msg.NumFixers} > \text{Cmsgs.msg.Squadrons}$

Condition I:

$$\begin{aligned} &\exists B, \quad B \in \{\text{true}, \text{false}\}, \\ &\quad (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ &\quad \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg.NumFixers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$$

Condition III: True

3.39: Does not reject $\text{Cmsgs.msg.NumJammers} > \text{Cmsgs.msg.Squadrons}$

Condition I:

$$\begin{aligned} &\exists B, \quad B \in \{\text{true}, \text{false}\}, \\ &\quad (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ &\quad \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg.NumJammers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$$

Condition III: True

3.40: Does not reject Cmsgs.msg.NumProcess > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad & B \in \{\text{true}, \text{false}\}, \\ & (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ & \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumProcess} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

3.41: Does not reject Cmsgs.msg.NumReceive > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad & B \in \{\text{true}, \text{false}\}, \\ & (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ & \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumReceive} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

3.42: Does not reject Cmsgs.msg.NumSend > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad & B \in \{\text{true}, \text{false}\}, \\ & (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ & \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumSend} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

3.43: Observes when $SR < 2$.

Condition I:

$$\begin{aligned} &(\exists B, \exists g, Active(B, g) \wedge \\ &(\exists e, 1 \leq e \leq NArmy[\neg B], \\ &(\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, \\ &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, \\ &\quad Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &\quad Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\quad BigEnough(B, g, j, e, k, Mainloop) \end{aligned}$$

Condition II:

Params.SampleRate < 2

Condition III: True

3.44: $NW > 0$ when $KF = 0$

Condition I:

$$\begin{aligned} &(\exists B, (\exists g, Active(B, g) \wedge \\ &\quad (Params.NumWTypes > 0) \\ & \\ &(\exists i, 1 \leq i \leq Params.NumWTypes, \\ &\quad (Army[B, g].Weapon[i].NumWeapon > 0) \wedge \\ &\quad (Army[B, g].Weapon[i].UseLimit > 0) \wedge \\ &\quad (Army[B, g].Weapon[i].Range > 0) \wedge \\ & \\ &(\exists e, 1 \leq e \leq NArmy[\neg B], \\ &(\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, \\ &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, \\ &\quad Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &\quad Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\quad Observe(B, g, j, e, k, Mainloop) \wedge InRange(B, g, i, e, k, Mainloop) \\ &)) \end{aligned}$$

Condition II: $(Army[B, g].Weapon[i].FireRate = 0)$

Condition III: True

3.45: Ax,Ay set in destroyed battalion

Condition I:

$$\begin{aligned}
 & (\text{Duration} > 0) \wedge (0 < \text{Mainloop} < \text{Duration}) \\
 & (\exists B, (\exists g, (\text{Army}[B, g].\text{Squadrons} > 0) \wedge \\
 & \quad (\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop} - 1) > 0))) \wedge \\
 & (\text{Params}.\text{NumWTypes} > 0) \\
 & (\exists i, 1 \leq i \leq \text{Params}.\text{NumWTypes}, \\
 & \quad (\text{Army}[B, g].\text{Weapon}[i].\text{NumWeapon} > 0) \wedge \\
 & \quad (\text{Army}[B, g].\text{Weapon}[i].\text{FireRate} > 0) \wedge \\
 & \quad (\text{Army}[B, g].\text{Weapon}[i].\text{UseLimit} > 0) \wedge \\
 & \quad (\text{Army}[B, g].\text{Weapon}[i].\text{Range} > 0) \wedge \\
 & (\exists e, 1 \leq e \leq \text{NArmy}[\neg B], \text{Active}(\neg B, e) \wedge \\
 & (\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \\
 & (\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \\
 & \quad \text{Endurance}(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\
 & \quad \text{Endurance}(B, g, j, \text{Mainloop} - 1) > 0 \wedge \\
 & \quad \text{Observe}(B, g, j, e, k, \text{Mainloop} - 1) \wedge \text{InRange}(B, g, i, e, k, \text{Mainloop}))
 \end{aligned}$$

Condition II: $\neg \text{Active}(B, g)$

Condition III:

$$\begin{aligned}
 & (\text{Duration} > \text{Mainloop} + 1) \wedge \text{Casualty}(\neg B, e, k, \text{Mainloop} + 1) \wedge \\
 & \quad \frac{\text{Endurance}(\neg B, e, k, \text{Mainloop}) + \text{Damage}(\neg B, e, k, \text{Mainloop}) - \text{Damage}(\neg B, e, k, \text{Mainloop} - 1)}{\text{Army}[\neg B, e].\text{Endurance}[k]} \\
 & 0.5 < \frac{\text{Endurance}(\neg B, e, k, \text{Mainloop}) + \text{Damage}(\neg B, e, k, \text{Mainloop}) - \text{Damage}(\neg B, e, k, \text{Mainloop} - 1)}{\text{Army}[\neg B, e].\text{Endurance}[k]} \\
 & \wedge (\nexists m, 1 \leq m \leq \text{NCmsgs}[\neg B], \text{Mimp}(\neg B, e, m, \text{Duration})_l \\
 & \wedge \neg \text{Mimp}(\neg B, e, m, \text{Mainloop})))
 \end{aligned}$$

Failure Regions in Version 4

4.1: Uninitialized field in pointer

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Active(B, f) \wedge Army[B, f].Report = g \wedge \\ &(\exists t, 0 \leq t < Duration, \\ &\quad t = Mainloop - RepT(B, g, f) - Army[B, g].ProcDelay - \\ &\quad \quad \quad \frac{Army[B, g].RecRate}{NumRec(B, g, Mainloop - Army[B, g].ProcDelay)} \wedge \\ &\quad EObserve(B, f, e, t) \wedge \\ &\quad (\exists t', 0 \leq t' < t, EObserve(B, g, e, t')))) \end{aligned}$$

Condition II: True

Condition III: True

4.2: No check for legal range of subscripts for Terrain

Condition I: $Duration > 0 \wedge Active(B, g)$

Condition II:

$$\begin{aligned} &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &(X_{B, g, j}(Mainloop) < 0 \vee X_{B, g, j}(Mainloop) > Params.XDelta \times MaxTerrain \vee \\ &Y_{B, g, j}(Mainloop) < 0 \vee Y_{B, g, j}(Mainloop) > Params.YDelta \times MaxTerrain)) \end{aligned}$$

Condition III: True

4.3: Wrong Battalion WeapSensativity used in Damage calculation

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge \\ &(\exists w, 1 \leq w \leq Params.NumWTypes, NumWeapon(\neg B, e, w, Mainloop) > 0 \wedge \\ &(\exists i, 1 \leq i \leq NumWeapon(\neg B, e, w, Mainloop), \\ &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\quad \left(\sqrt{(X_{B, g, j}(Mainloop) - ax_{\neg B, e, w, i}(Mainloop))^2 +} \right. \\ &\quad \left. \sqrt{(Y_{B, g, j}(Mainloop) - ay_{\neg B, e, w, i}(Mainloop))^2} \right. \\ &\quad \quad \quad \left. < Army[\neg B, e].Weapon[w].Radius) \end{aligned}$$

Condition II: $Army[B, g].WeapSensativity[w] \neq Army[\neg B, e].WeapSensativity[w]$

Condition III:

$$\begin{aligned} &(Army[\neg B, e].Weapon[w].Damage > 0) \wedge \\ &(\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Duration) \\ &\quad \wedge \neg Mimp(B, g, m, Mainloop - 1)))) \end{aligned}$$

4.4: Wrong Battalion VWEffect used in Observation Jamming

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Params.SampleRate > 2 \wedge \\ &(\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &BigEnough(B, g, j, e, k, Mainloop) \wedge Clear(B, g, j, e, k, Mainloop)) \end{aligned}$$

Condition II:

$$\begin{aligned} &Army[B, g].VWEffect \neq Army[\neg B, e].VWEffect \wedge \\ &(\exists x', y', x'', y'', x' = X_{B,g,j}(Mainloop - 1) \wedge y' = Y_{B,g,j}(Mainloop - 1) \wedge \\ &x'' = X_{\neg B,e,k}(Mainloop - 1) \wedge y'' = Y_{\neg B,e,k}(Mainloop - 1) \wedge \\ &(\exists n, 1 \leq n \leq Params.SampleRate, \\ &WO\left(x' \times \frac{n \times (x' - x'')}{Params.SampleRate}, y' \times \frac{n \times (y' - y'')}{Params.SampleRate}, Mainloop\right) > 0)) \end{aligned}$$

Condition III:

$$\begin{aligned} &(Obvious(B, g, j, e, k, Mainloop) \wedge \\ &(\nexists t, 0 \leq t < Duration, t \neq Mainloop \wedge EObserve(B, g, e, t))) \vee \\ &(\neg Obvious(B, g, j, e, k, Mainloop) \wedge \\ &(\forall t, 0 \leq t < Duration, t \neq Mainloop \wedge \neg EObserve(B, g, e, t)))) \end{aligned}$$

4.5: No Check for Destroyed Squad before Initializing Location Intensity

and

4.6: No Check for Destroyed Squad before Observation

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$\begin{aligned} &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) \leq 0 \wedge \\ &(\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &Observe(B, g, j, e, k, Mainloop))) \end{aligned}$$

Condition III: True

4.7: Wrong ArmyId in Check for Destroyed Battalion in Observation

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\ (\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, j = k \wedge \text{Endurance}(B, g, j, \text{Mainloop}) \leq 0$$

Condition III:

$$(\exists k', 1 \leq k' \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k', \text{Mainloop}) > 0 \wedge \\ \text{Observe}(\neg B, e, k', g, j, \text{Mainloop})) \wedge (\forall t, 0 \leq t < \text{Duration}, \neg \text{EObserve}(\neg B, e, g, t))))$$

4.8: Counting loop runs off end of Observation List

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge \text{EObserve}(B, g, e, \text{Mainloop} - 1) \wedge \\ (\exists w, 1 \leq w \leq \text{Params.NumWTypes}, \text{NumWeapon}(B, g, w, \text{Mainloop}) > 0 \wedge \\ \text{Army}[B, g].\text{WeapPriority}[e, w] > 0)$$

Condition II:

$$|\{k \ni 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons} \wedge \text{Endurance}(\neg B, e, k, \text{Mainloop} - 1) > 0 \wedge \\ (\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop}) > 0 \wedge \\ \text{Observe}(B, g, j, e, k, \text{Mainloop} - 1))\}| = 1$$

Condition III: True

4.9: Wrong initialization of Observation List

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge \\ (\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop}) > 0 \wedge \\ (\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\ \text{Observe}(B, g, j, e, k, \text{Mainloop})))$$

Condition II:

$$(\exists k', 1 \leq k' \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k', \text{Mainloop}) > 0 \wedge k \neq k' \wedge \\ (\exists j', 1 \leq j' \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j', \text{Mainloop}) > 0 \wedge \\ \text{Observe}(B, g, j', e, k', \text{Mainloop}))))$$

Condition III: True

4.10: Spurious Check for Casualty Squadrons in Observation

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$(\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ Casualty(B, g, j, Mainloop) \wedge \\ (\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ Observe(B, g, j, e, k, Mainloop))$$

Condition III:

$$(\neg \exists j', 1 \leq j' \leq Army[B, g].Squadrons, Endurance(B, g, j', Mainloop) > 0 \wedge \\ \neg Casualty(B, g, j', Mainloop) \wedge Observe(B, g, j', Mainloop)) \wedge \\ (\nexists t, 1 \leq t \leq Duration, t \neq Mainloop \wedge EObserve(B, g, e, t))$$

4.11: Incomplete Command Message Implementation

Condition I:

$$Active(B, g) \wedge \\ (\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Mainloop) \wedge \neg Mimp(B, g, m, Mainloop - 1))$$

Condition II:

$$(\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop - 1) > 0 \wedge \\ Casualty(B, g, j, Mainloop - 1))$$

Condition III:

$$(NumJam(B, g, Mainloop - 1) = 0 \wedge Army[B, g].CommJamEff > 0 \wedge \\ (\exists e, Active(\neg B, e), \\ \frac{\sqrt{(X_{\neg B, e}(Mainloop - 1) - X_{B, g}(Mainloop - 1))^2 + \\ (Y_{\neg B, e}(Mainloop - 1) - Y_{B, g}(Mainloop - 1))^2}}{\\ < Army[B, g].CommJamRadius) \wedge Army[B, g].CommJamPriority[e] > 0) \vee \\ (NumWeapon(B, g, 1, Mainloop - 1) \\ < |\{k \ni \exists e, j, Observe(B, g, j, e, k, Mainloop - 1)\}| \wedge \\ Army[B, g].Weapon[1].Damage \neq Army[B, g].Weapon[2].Damage)$$

4.12: Misordered Observation functions

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$\begin{aligned} & (\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\ & (X_{\neg B, e, k}(\text{Mainloop}) \neq X_{\neg B, e, k}(\text{Mainloop} - 1)) \vee \\ & Y_{\neg B, e, k}(\text{Mainloop}) \neq Y_{\neg B, e, k}(\text{Mainloop} - 1)) \end{aligned}$$

Condition III:

$$\begin{aligned} & (\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop}) > 0 \wedge \\ & \neg \text{Observe}(B, g, j, e, k, \text{Mainloop} - 1) \wedge \text{Observe}(B, g, j, e, k, \text{Mainloop})) \end{aligned}$$

4.13: Spurious check in Message Processing

Condition I:

$$\begin{aligned} & Active(B, g) \wedge Active(\neg B, e) \wedge Active(B, f) \wedge \text{Army}[B, f].\text{Report} = g \wedge \\ & (\exists d, d = \text{RepT}(B, g, f) + \frac{\text{Army}[B, g].\text{RecRate}}{\text{NumRec}(B, g, \text{Mainloop})}, \\ & (\exists t, t + d < \text{Mainloop} < t + d + \text{Army}[B, g].\text{ProcDelay}, \text{EObserve}(B, f, e, t)) \end{aligned}$$

Condition II:

$$\begin{aligned} & (\exists f', Active(B, f'), \text{Army}[B, f']. \text{Report} = g \wedge \\ & (\exists t', t' = \text{Mainloop} - (d + \text{Army}[B, f']. \text{SendRate} - \text{Army}[B, f]. \text{SendRate}), \\ & (\exists e', Active(\neg B, e') \wedge e \neq e', \text{EObserve}(B, f', e', t')) \end{aligned}$$

Condition III:

$$\begin{aligned} & (\nexists t'', 1 \leq t'' \leq \text{Duration}, \text{EObserve}(B, g, e', t'')) \vee \\ & (t'' \neq t' \wedge (\exists f'', Active(B, f'') \wedge \text{Army}[B, f'']. \text{Report} = g, \\ & \text{EObserve}(B, f'', e', t'')))) \end{aligned}$$

4.14: Wrong index in Message Processing

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Active(B, f) \wedge Army[B, f].Report = g \wedge \\ &(\exists d, d = RepT(B, g, f) + \frac{Army[B, g].RecRate}{NumRec(B, g, Mainloop)}, \\ &(\exists t, t + d < Mainloop < t + d + Army[B, g].ProcDelay, EObserve(B, f, e, t)) \end{aligned}$$

Condition II:

$$\begin{aligned} &(\exists f', Active(B, f'), Army[B, f'].Report = g \wedge \\ &Army[B, f'].Priority < Army[B, f].Priority \wedge \\ &(\exists e', Active(\neg B, e') \wedge e \neq e', EObserve(B, f', e', t)) \end{aligned}$$

Condition III:

$$\begin{aligned} &(\nexists t', 1 \leq t' \leq Duration, EObserve(B, g, e', t')) \vee \\ &(t' < t \wedge (\exists f'', Active(B, f'') \wedge Army[B, f''].Report = g, \\ &EObserve(B, f'', e', t')))) \end{aligned}$$

4.15: No Check for Engaged before Observed from Reports

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(B, f) \wedge Active(\neg B, e) \wedge Army[B, f].Report = g \wedge \\ &(\exists t, 0 \leq t < Duration, \\ &t = Duration - RepT(B, g, f) - Army[B, g].ProcDelay - \\ &\frac{Army[B, g].RecRate}{NumRec(B, g, Duration - Army[B, g].ProcDelay)} \wedge \\ &EObserve(B, f, e, t - 1)) \end{aligned}$$

Condition II:

$$\begin{aligned} &(\exists t', 0 \leq t' < Duration, EObserve(B, g, e, t - 1) \wedge \\ &(\exists w, 1 \leq w \leq Params.NumWTypes, NumWeapon(B, g, w, t) > 0 \wedge \\ &Army[B, g].WeapPriority[e, w] > 0 \wedge InRange(B, g, e, w, t))) \end{aligned}$$

Condition III: True

4.16: Spurious Check for ObsJamEff=0

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge \\ &(\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop}) > 0 \wedge \\ &(\exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\ &\text{BigEnough}(B, g, j, e, k, \text{Mainloop}) \wedge \text{Clear}(B, g, j, e, k, \text{Mainloop})) \end{aligned}$$

Condition II:

$$\begin{aligned} &(\exists e', 1 \leq e' \leq \text{NArmy}[\neg B], \text{Army}[\neg B, e']. \text{Squadrons} > 0 \wedge \\ &\text{Army}[\neg B, e']. \text{ObsJamEff} = 0) \end{aligned}$$

Condition III:

$$\begin{aligned} &\neg \text{Obvious}(B, g, j, e, k, \text{Mainloop}) \wedge \\ &(\forall t, 1 \leq t \leq \text{Duration}, \text{SomeObserve}(B, g, e, k, t))) \end{aligned}$$

4.18: Reversed Parameters in Observation

Condition I: $Active(B, g) \wedge Active(\neg B, e) \wedge EObserve(B, g, e, \text{Mainloop})$

Condition II: $g \neq e \wedge \neg EObserve(B, e, g, \text{Mainloop})$

Condition III: $e > \text{NArmy}[B] \vee \text{Duration} > \text{Mainloop} + 1$

4.19: Abort in SetCoordinates when Battalion leaves Terrain and

4.20: Abort in SlopeIntensity when Battalion leaves Terrain

Condition I: $Active(B, g)$

Condition II:

$$\begin{aligned} &(X_{B,g}(\text{Mainloop}) \leq 0 \vee X_{B,g}(\text{Mainloop}) \geq \text{Params.XDelta} \times \text{MaxTerrain}) \wedge \\ &(Y_{B,g}(\text{Mainloop}) \leq 0 \vee Y_{B,g}(\text{Mainloop}) \geq \text{Params.YDelta} \times \text{MaxTerrain}) \end{aligned}$$

Condition III: True

4.21: NumFixers Exceeds Maximum Value

Condition I: $Active(B, g)$

Condition II:

$$\left(\sum_{j=1}^{Army[B,g].Squadrons} \begin{cases} 1 & \text{if } \neg Casualty(B, g, j, Mainloop - 2) \wedge \\ & Endurance(B, g, j, Mainloop - 1) \leq 0 \\ 0 & \text{otherwise} \end{cases} \right) > s(B, g, Mainloop) - NumFix(B, g, Mainloop - 1)$$

Condition III:

$$\begin{aligned} & (\exists j, 1 \leq j \leq Army[B, g].Squadrons, Casualty(B, g, j, Mainloop) \wedge \\ & (\exists r, r = \frac{Army[B, g].FixRate \times NumFix(B, g, j, Mainloop - 1)}{\sum_{j'=1}^{Army[B, g].Squadrons} \begin{cases} 1 & \text{if } Casualty(B, g, j', Mainloop) \\ 0 & \text{otherwise} \end{cases}}), \\ & r > Suppl(B, g, Mainloop) \wedge \\ & r > (Army[B, g].Endurance - Endurance(B, g, j, Mainloop))) \end{aligned}$$

4.22: Observation when Params.SampleRate < 2

Condition I:

$$\begin{aligned} & (\exists B, \exists g, Active(B, g) \wedge \\ & (\exists e, 1 \leq e \leq NArmy[\neg B], \\ & (\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, \\ & (\exists j, 1 \leq j \leq Army[B, g].Squadrons, \\ & Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ & Endurance(B, g, j, Mainloop) > 0 \wedge \\ & BigEnough(B, g, j, e, k, Mainloop) \end{aligned}$$

Condition II:

$$Params.SampleRate < 2$$

Condition III: True

4.24: Wrong parameter declaration in Command Message Processing

Condition I:

$$\begin{aligned} &Active(B, g) \\ &(\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Mainloop) \wedge \neg Mimp(B, g, m, Mainloop - 1)) \end{aligned}$$

Condition II:

$$\begin{aligned} &(\exists n, 1 \leq n \leq NCmsgs[B] \wedge m \neq n, \\ &Mimp(B, g, n, Mainloop) \wedge \neg Mimp(B, g, n, Mainloop - 1))) \end{aligned}$$

Condition III: True

4.26: Priority Queue not Preserved in Message Processing

Condition I:

$$\begin{aligned} &Active(B, g) \\ &(\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Mainloop) \wedge \neg Mimp(B, g, m, Mainloop - 1) \wedge \\ &(\exists n, 1 \leq n \leq NCmsgs[B] \wedge m \neq n, \\ &Mimp(B, g, n, Mainloop) \wedge \neg Mimp(B, g, n, Mainloop - 1))) \end{aligned}$$

Condition II:

$$\begin{aligned} &(Cmsgs[B, m].Priority > Cmsgs[B, n].Priority) \wedge \\ &(Cmsgs[B, m].msg \neq Cmsgs[B, n].msg)) \end{aligned}$$

Condition III: True

Failure Regions in Version 5

5.1: Bad list manipulation

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge \\ &\exists j, 1 \leq k \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &BigEnough(B, g, j, e, k, Mainloop) \wedge \neg Clear(B, g, j, e, k, Mainloop) \end{aligned}$$

Condition II:

$$\exists k', 1 \leq k' < k, Endurance(\neg B, e, k', Mainloop) > 0 \wedge Observe(B, g, j, e, k', Mainloop)$$

Condition III: True

5.2: \neq instead of \geq in check for busy processors

Condition I:

$$\begin{aligned} &Active(B, g) \wedge NCmsgs[B] > 0 \\ &\exists m, 1 \leq m \leq NCmsgs[B], \\ &RecT(B, g, m) + RecDelay(B, g, RecT(B, g, m)) + QueDelay(B, g, m) = Mainloop \wedge \\ &NumProcess(B, g, Mainloop) > 0 \end{aligned}$$

Condition II:

$$\begin{aligned} &\left(\sum_{n=1}^{NCmsgs[B]} \begin{cases} 0 & \text{if } (n = m) \vee Cmsgs[B, n].Dest \neq g \vee \\ & RecT(B, g, n) + RecDelay(B, g, RecT(B, g, n)) + \\ & QueDelay(B, g, n) > Mainloop \\ 1 & \text{otherwise} \end{cases} \right) \\ &+ \left(\sum_{f=1}^{NArmy[B]} \begin{cases} 0 & \text{if } Army[B, f].Report \neq g \vee \\ & (\forall t, 1 \leq t \leq Mainloop - RepT(B, g, f) \\ & \quad - RecDelay(B, g, RepT(B, g, f))), \\ & \neg SomeObserve(B, f, t) \\ 1 & \text{otherwise} \end{cases} \right) \\ &\geq NumProcess(B, g, Mainloop) \end{aligned}$$

Condition III: $Mimp(B, g, m, Duration) \wedge Cmsgs[B, m].msg \neq Army[B, g]$

5.3: Squadrons with initial endurance ≤ 0 not destroyed

Condition I: True

Condition II:

$$\begin{aligned} & \exists B, B \in \{\text{false}, \text{true}\}, \text{NArmy}[B] > 0 \wedge \\ & \quad \exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B, g].\text{Squadrons} > 0 \\ & \quad \exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \\ & \quad \text{Army}[B, g].\text{Endurance}[j] \leq 0 \end{aligned}$$

Condition III: $\text{Duration} = 0$

5.4: Squadrons with command endurance ≤ 0 not destroyed

Condition I:

$$\begin{aligned} & \text{Active}(B, g) \wedge \text{NCmsgs}[B] > 0 \wedge \\ & \quad \exists m, 1 \leq m \leq \text{NCmsgs}[B], \text{Mimp}(B, g, m, \text{Mainloop}) \end{aligned}$$

Condition II:

$$\begin{aligned} & \exists j, 1 \leq j \leq \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}, \\ & \quad \text{Cmsgs}[B, m].\text{msg}.\text{Endurance}[j] \leq 0 \end{aligned}$$

Condition III: $\text{Duration} = \text{Mainloop}$

5.5: Position and PreArmy values set before Army values finalized

Condition I:

$$\begin{aligned} & \text{Active}(B, g) \wedge \text{NCmsgs}[B] > 0 \wedge \\ & \quad (\exists m, 1 \leq m \leq \text{NCmsgs}[B], \\ & \quad \text{Mimp}(B, g, m, \text{Mainloop}) \wedge \neg \text{Mimp}(B, g, m, \text{Mainloop} - 1)) \end{aligned}$$

Condition II: True

Condition III: $\text{Duration} = \text{Mainloop}$

5.6: Improperly rejected Duration = 0

and

5.14: Positions not initialized if Duration = 0

Condition I: True

Condition II: Duration = 0

Condition III: True

5.7: Improperly rejected NArmy = 0

Condition I: True

Condition II: $\exists B, B \in \{\text{false}, \text{true}\}, \text{NArmy}[B] = 0$

Condition III: True

5.8: Dequeues messages for existing, not available, processors

Condition I:

$\text{Active}(B, g) \wedge \text{NCmsgs}[B] > 0 \wedge \text{NumProcess}(B, g, \text{Mainloop}) > 0 \wedge$

$\exists t, t = \text{Mainloop} - \text{Army}[B, g].\text{ProcDelay} - \text{RepT}(B, g, f)$

$- \text{RecDelay}(B, g, \text{RepT}(B, g, f)), 1 \leq t \leq \text{Duration} \wedge$

$$\exists n, n = \left(\sum_{m=1}^{\text{NCmsgs}[B]} \begin{cases} 1 & \text{if } \text{Cmsgs}[B, m].\text{Dest} = g \wedge \\ & \text{RecT}(B, g, m) + \text{RecDelay}(B, g, \text{RecT}(B, g, m)) \leq \text{Mainloop} \wedge \\ & \neg \text{Mimp}(B, g, m, \text{Mainloop}) \\ 0 & \text{otherwise} \end{cases} \right) + \left(\sum_{f=1}^{\text{NArmy}[B]} \begin{cases} \left(\sum_{t'=t}^{\text{Mainloop} - \text{RepT}(B, g, f)} \begin{cases} 1 & \text{if } \text{SomeObserve}(B, f, t') \\ 0 & \text{otherwise} \end{cases} \right) & \text{if } \text{Army}[B, g].\text{Report} = g \\ 0 & \text{otherwise} \end{cases} \right)$$

Condition II: $n > \text{NumProcess}(B, g, \text{Mainloop})$

Condition III: True

5.9: Improperly rejected Weather Start > Duration

Condition I: True

Condition II: $\exists w, 1 \leq w \leq \text{Params.NumWEvents}, \text{Weather}[w].\text{TStart} > \text{Duration}$

Condition III: True

5.10: Improperly rejected Weather End > Duration

Condition I: True

Condition II: $\exists w, 1 \leq w \leq \text{Params.NumWEvents}, \text{Weather}[w].\text{TEnd} > \text{Duration}$

Condition III: True

5.11: Improperly rejected CommJamRadius = 0

Condition I: True

Condition II:

$\exists B, B \in \{\text{false}, \text{true}\}, \text{NArmy}[B] > 0 \wedge$

$\exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B, g].\text{CommJamRadius} = 0$

Condition III: True

5.12: Improperly rejected ObsJamRadius = 0

Condition I: True

Condition II:

$\exists B, B \in \{\text{false}, \text{true}\}, \text{NArmy}[B] > 0 \wedge$

$\exists g, 1 \leq g \leq \text{NArmy}[B], \text{Army}[B, g].\text{ObsJamRadius} = 0$

Condition III: True

5.13: Segmentation violation when battalion leaves terrain grid and

5.41: Altitude and IntnstyLoc poorly defined when Battalion leaves Terrain grid

and

5.42: Use of borders to initialize maximum and minimum for W,H calc causes problems when squadrons leave Terrain-defined area

Condition I: $(\text{Duration} > 0)$

Condition II:

$\exists B, g, \text{Active}(B, g) \wedge$

$(X_{B,g}(\text{Mainloop}) \geq \text{Params.XDelta} \times \text{MaxTerrain} \vee$

$Y_{B,g}(\text{Mainloop}) \geq \text{Params.YDelta} \times \text{MaxTerrain} \vee$

$X_{B,g}(\text{Mainloop}) < 0 \vee Y_{B,g}(\text{Mainloop}) < 0)$

Condition III: True

5.15: No check to see if $NW = 0$ before setting Action to Engaged

Condition I:

$$\begin{aligned}
 &Active(B, g) \wedge Active(\neg B, e) \wedge Mainloop > 1 \wedge Params.NumWTypes > 0 \wedge \\
 &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\
 &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\
 &Observe(B, g, j, e, k, Mainloop - 1) \wedge \\
 &\exists w, 1 \leq w \leq Params.NumWTypes, \\
 &Army[B, g].Weapon[w].Range \geq \\
 &\sqrt{(X_{B,g}(Mainloop) - X_{\neg B,e,k}(Mainloop - 1))^2 +} \\
 &\sqrt{(Y_{B,g}(Mainloop) - Y_{\neg B,e,k}(Mainloop - 1))^2}
 \end{aligned}$$

Condition II:

$$\begin{aligned}
 &Army[B, g].Weapon[w].FireRate \leq 0 \vee \\
 &Army[B, g].WeapPriority[e, w] \leq 0 \vee \\
 &Army[B, g].Weapon[w].UseLimit \leq 0 \vee \\
 &NumWeapon(B, g, w, Mainloop) \leq 0 \vee \\
 &Army[B, g].Weapon[w].UseLimit \leq \\
 &\left(\sum_{t=2}^{Mainloop} \sum_{i=1}^{NumWeapon(B, g, w, t)} \begin{cases} 1 & \text{if } ax_{B,g,w,i}(t) \neq \infty \\ 0 & \text{otherwise} \end{cases} \right)
 \end{aligned}$$

Condition III:

$$\begin{aligned}
 &\forall t, 1 \leq t \leq Duration, \forall w', 1 \leq w' \leq Params.NumWTypes, \\
 &NumWeapon(B, g, w', t) > 0 \wedge \forall i, 1 \leq i \leq NumWeapon(B, g, w', t), \\
 &\forall k', 1 \leq k' \leq Army[\neg B, e].Squadrons, \\
 &(ax_{B,g,w',i}(t) \neq X_{\neg B,e,k'}(t) \vee ay_{B,g,w',i}(t) \neq Y_{\neg B,e,k'}(t)) \wedge \\
 &\nexists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Duration) \wedge \neg Mimp(B, g, m, Mainloop - 1)
 \end{aligned}$$

5.16: Improper treatment of case where $KF = 0$

Condition I:

$$\begin{aligned}
 &Active(B, g) \wedge Active(\neg B, e) \wedge Mainloop > 1 \wedge Params.NumWTypes > 0 \wedge \\
 &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\
 &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\
 &Observe(B, g, j, e, k, Mainloop - 1) \wedge \\
 &\exists w, 1 \leq w \leq Params.NumWTypes, \\
 &Army[B, g].Weapon[w].Range \geq \\
 &\sqrt{(X_{B,g}(Mainloop) - X_{\neg B,e,k}(Mainloop - 1))^2 +} \\
 &\sqrt{(Y_{B,g}(Mainloop) - Y_{\neg B,e,k}(Mainloop - 1))^2}
 \end{aligned}$$

Condition II: $Army[B, g].Weapon[w].FireRate \leq 0$

Condition III:

$$\begin{aligned}
 &Army[B, g].WeapPriority[e, w] > 0 \wedge \\
 &Army[B, g].Weapon[w].UseLimit > \\
 &\left(\sum_{t=2}^{Mainloop} \sum_{i=1}^{NumWeapon(B, g, w, t)} \begin{cases} 1 & \text{if } ax_{B, g, w, i}(t) \neq \infty \\ 0 & \text{otherwise} \end{cases} \right) \wedge \\
 &NumWeapon(B, g, w, Mainloop) > 0 \wedge \forall t, 1 \leq t \leq Duration, \\
 &\forall w', 1 \leq w' \leq Params.NumWTypes, NumWeapon(B, g, w', t) > 0 \wedge \\
 &\forall i, 1 \leq i \leq NumWeapon(B, g, w', t), \\
 &\forall k', 1 \leq k' \leq Army[\neg B, e].Squadrons, \\
 &(ax_{B, g, w', i}(t) \neq X_{\neg B, e, k'}(t) \vee ay_{B, g, w', i}(t) \neq Y_{\neg B, e, k'}(t)) \wedge \\
 &\nexists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Duration) \wedge \neg Mimp(B, g, m, Mainloop - 1)
 \end{aligned}$$

5.17: Improper Observation when $H = Z$

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$\begin{aligned}
& \exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop}) > 0 \wedge \\
& \exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\
& \text{BigEnough}(B, g, j, e, k, \text{Mainloop}) \wedge \text{Obvious}(B, g, j, e, k, \text{Mainloop}) \wedge \\
& \neg \text{Clear}(B, g, j, e, k, \text{Mainloop}) \wedge \\
& xgj = x_{B,g,j}(\text{Mainloop} - 1) \wedge ygj = y_{B,g,j}(\text{Mainloop} - 1) \wedge \\
& xek = x_{\neg B,e,k}(\text{Mainloop} - 1) \wedge yek = y_{\neg B,e,k}(\text{Mainloop} - 1) \wedge \\
& (\forall a, a', c, c', z, z', a = \lfloor \frac{xgj}{\text{Params.XDelta}} \rfloor \wedge a' = \lfloor \frac{xek}{\text{Params.XDelta}} \rfloor \wedge \\
& \quad c = \lfloor \frac{ygj}{\text{Params.YDelta}} \rfloor \wedge c' = \lfloor \frac{yek}{\text{Params.YDelta}} \rfloor \wedge \\
& \quad z = \text{Alt}(a, c, xgj, ygj) \wedge z' = \text{Alt}(a', c', xek, yek) \wedge \\
& (\forall n, 1 \leq n < \text{Params.SampleRate} - 1, \\
& (\exists r, p, q, r = \frac{n}{\text{Params.SampleRate}}, p = \lfloor \frac{xgj + r \times (xek - xgj)}{\text{Params.XDelta}} \rfloor, q = \lfloor \frac{ygj + r \times (yek - ygj)}{\text{Params.YDelta}} \rfloor, \\
& (z + r \times (z' - z)) \geq \text{Alt}(p, q, xgj + r \times (xek - xgj), ygj + r \times (yek - ygj))))))
\end{aligned}$$

Condition III: $\forall t, 1 \leq t \leq \text{Duration}, \neg E\text{Observe}(B, g, e, t)$

5.18: Does not reject $\text{Army.NumFixers} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned}
& (\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\
& \quad \text{Army}[\text{true}, B].\text{NumFixers} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\
& (\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\
& \quad \text{Army}[\text{false}, B].\text{NumFixers} > \text{Army}[\text{false}, B].\text{Squadrons})
\end{aligned}$$

Condition III: True

5.19: Does not reject Cmsgs.msg.NumFixers > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad B \in \{\text{true}, \text{false}\}, \\ (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumFixers} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

5.20: Does not reject Army.NumJammers > Army.Squadrons

Condition I: (Duration ≥ 0)

Condition II:

$$\begin{aligned} (\exists B, B \in \{1 \dots \text{NArmy}[\text{true}]\}, \\ \text{Army}[\text{true}, B].\text{NumJammers} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ (\exists B, B \in \{1 \dots \text{NArmy}[\text{false}]\}, \\ \text{Army}[\text{false}, B].\text{NumJammers} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

5.21: Does not reject Cmsgs.msg.NumJammers > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad B \in \{\text{true}, \text{false}\}, \\ (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumJammers} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

5.22: Does not reject $\text{Army.NumProcess} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumProcess} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumProcess} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

5.23: Does not reject $\text{Cmsgs.msg.NumProcess} > \text{Cmsgs.msg.Squadrons}$

Condition I:

$$\begin{aligned} &\exists B, \quad B \in \{\text{true}, \text{false}\}, \\ &\quad (\exists f, 1 \leq f \leq N\text{Army}[B], \\ &\quad \quad (\exists m, m \in \{1 \dots N\text{Cmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg.NumProcess} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$$

Condition III: True

5.24: Does not reject $\text{Army.NumReceive} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumReceive} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumReceive} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

5.25: Does not reject Cmsgs.msg.NumReceive > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad B \in \{\text{true}, \text{false}\}, \\ (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumReceive} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

5.26: Does not reject Army.NumSend > Army.Squadrons

Condition I: ($\text{Duration} \geq 0$)

Condition II:

$$\begin{aligned} (\exists B, B \in \{1 \dots \text{NArmy}[\text{true}]\}, \\ \text{Army}[\text{true}, B].\text{NumSend} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ (\exists B, B \in \{1 \dots \text{NArmy}[\text{false}]\}, \\ \text{Army}[\text{false}, B].\text{NumSend} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

5.27: Does not reject Cmsgs.msg.NumSend > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad B \in \{\text{true}, \text{false}\}, \\ (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumSend} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

5.28: Improperly rejected SampleRate = 1

Condition I: True

Condition II: Params.SampleRate = 1

Condition III: True

5.30: Improperly rejected Army.Weapon.Range = 0

Condition I:

$$\exists B, B \in \{\text{false}, \text{true}\}, N\text{Army}[B] > 0 \wedge \\ \exists g, 1 \leq g \leq N\text{Army}[B], \text{Params.NumWTypes} > 0$$

Condition II: $\exists w, 1 \leq w \leq \text{Params.NumWTypes}, \text{Army}[B, g].\text{Weapon}[w].\text{Range} = 0$

Condition III: True

5.31: KA initialized to 0 not NK

Condition I: $\text{Active}(B, g) \wedge \text{Params.NumWTypes} > 0$

Condition II:

$$\exists w, 1 \leq w \leq \text{Params.NumWTypes}, \text{Army}[B, g].\text{Weapon}[w].\text{NumWeapon} > 0$$

Condition III:

$$\text{Active}(\neg B, e) \wedge \text{Params.SampleRate} > 1 \wedge \\ \exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop}) > 0 \wedge \\ \exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\ \text{Observe}(B, g, j, e, k, \text{Mainloop} - 1) \wedge \text{InRange}(B, g, w, e, k, \text{Mainloop} - 1) \wedge \\ \text{NumWeapon}(B, g, w, \text{Mainloop}) > 0 \wedge \text{Army}[B, g].\text{WeapPriority}[e, w] > 0 \wedge \\ \text{Army}[B, g].\text{Weapon}[w].\text{UseLimit} > 0$$

5.32: Weather movement components improperly rejected if negative

Condition I: $\text{Params.NumWEvents} > 0$

Condition II:

$$\exists w, 1 \leq w \leq \text{Params.NumWEvents}, \\ \text{Weather}[w].dWX < 0 \vee \text{Weather}[w].dWY < 0$$

Condition III: True

5.33: Command implemented in destroyed battalion

Condition I:

$$1 \leq \text{Mainloop} \leq \text{Duration} \wedge \exists B, B \in \{\text{true}, \text{false}\}, \\ \text{NArmy}[B] > 0 \wedge \text{NCmsgs}[B] > 0 \wedge \\ \exists m, 1 \leq m \leq \text{NCmsgs}[B], 1 \leq \text{Cmsgs}[B, m].\text{Dest} \leq \text{NArmy}[B] \wedge \\ \exists g, g = \text{Cmsgs}[B, m].\text{Dest}, \text{Army}[B, g].\text{Squadrons} > 0 \wedge \\ (\exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Cmsgs}[B, m].\text{Time}) > 0) \wedge \\ \text{Mimp}(B, g, m, \text{Mainloop}) \wedge \neg \text{Mimp}(B, g, m, \text{Mainloop} - 1)$$

Condition II:

$$(\nexists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop}) > 0) \wedge \\ (\text{Cmsgs}[B, m].\text{msg.Squadrons} \neq \text{Army}[B, g].\text{Squadrons} \vee \\ (\exists j, 1 \leq j \leq \text{Cmsgs}[B, m].\text{msg.Squadrons}, \text{Cmsgs}[B, m].\text{msg.Endurance}[j] > 0) \vee \\ \text{Cmsgs}[B, m].\text{msg.X} \neq X_{B,g}(\text{Mainloop}) \vee \text{Cmsgs}[B, m].\text{msg.Y} \neq Y_{B,g}(\text{Mainloop}))$$

Condition III: True

5.34: V calculated using possible destroyed squadrons with command

Condition I:

$$\text{Active}(B, g) \wedge \text{NCmsgs}[B] > 0 \wedge \\ \exists m, 1 \leq m \leq \text{NCmsgs}[B], \text{Mimp}(B, g, m, \text{Mainloop}) \wedge \neg \text{Mimp}(B, g, m, \text{Mainloop} - 1) \wedge \\ \text{Cmsgs}[B, m].\text{msg.Squadrons} > 0$$

Condition II:

$$\exists j, 1 \leq j \leq \text{Cmsgs}[B, m].\text{msg.Squadrons}, \text{Cmsgs}[B, m].\text{msg.Endurance}[j] \leq 0 \wedge \\ (\nexists j', 1 \leq j' \leq \text{Cmsgs}[B, m].\text{msg.Squadrons}, \text{Cmsgs}[B, m].\text{msg.Endurance}[j'] > 0 \wedge \\ \text{Cmsgs}[B, m].\text{msg.V0}[j'] > \text{Cmsgs}[B, m].\text{msg.V0}[j]) \wedge \\ \text{Cmsgs}[B, m].\text{msg.V0}[j] > 0$$

Condition III:

$$\nexists m', 1 \leq m' \leq \text{NCmsgs}[B], \\ \text{Mimp}(B, g, m, \text{Duration}) \wedge \neg \text{Mimp}(B, g, m, \text{Mainloop} - 1)$$

5.35: NumFixers can be greater than original value

Condition I:

$$\begin{aligned} &Active(B, g) \wedge NumFix(B, g, Mainloop - 1) > 0 \wedge \\ &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &Casualty(B, g, j, Mainloop - 1) \wedge \neg Casualty(B, g, j, Mainloop)) \end{aligned}$$

Condition II:

$$\begin{aligned} &(NumFix(B, g, Mainloop - 1) + \\ &(NumCas(B, g, Mainloop - 1) - NumCas(B, g, Mainloop) \times \frac{NumFix(B, g, Mainloop - 1)}{s(B, g, Mainloop - 1)}) \\ &> s(B, g, Mainloop - 1) \end{aligned}$$

Condition III:

$$\begin{aligned} &\nexists m, 1 \leq m \leq NCmsgs[B], \\ &Mimp(B, g, m, Duration) \wedge \neg Mimp(B, g, m, Mainloop - 1) \wedge \\ &Duration > Mainloop + 1 \wedge NumCas(B, g, Mainloop) > 0 \end{aligned}$$

5.37: gold observes when version does not

and

5.43: Version fails to engage

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Active(B, f) \wedge \\ &Army[B, f].Report = g \wedge Mainloop > Army[B, f].ObsXpire \wedge \\ &NumSend(B, g, Mainloop - Army[B, f].ObsXpire) > 0 \end{aligned}$$

Condition II:

$$\begin{aligned} &EObserve(B, f, e, Mainloop - Army[B, f].ObsXpire) \wedge \\ &Army[B, f].ObsXpire = RepT(B, f, g) + Army[B, g].ProcDelay + \\ &RecDelay(B, g, Mainloop - Army[B, f].ObsXpire + RepT(B, f, g)) \end{aligned}$$

Condition III:

$$\begin{aligned} &(\nexists f', Active(B, f') \wedge Army[B, f'].Report = g, \\ &\exists t, 1 \leq t \leq Duration, EObserve(B, f', e, t)) \wedge \\ &(\nexists t, 1 \leq t \leq Duration, EObserve(B, g, e, t)) \end{aligned}$$

5.39: Current, not previous, observations sent in report messages

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(B, f) \wedge Active(\neg B, e) \wedge Army[B, f].Report = g \wedge \\ &(\exists j, 1 \leq j \leq Army[B, f].Squadrons, Endurance(B, f, j, Mainloop) > 0 \wedge \\ &(\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &Observe(B, f, j, e, k, Mainloop) \wedge Army[B, f].NumSend > 0 \end{aligned}$$

Condition II: $\neg Observe(B, f, j, e, k, Mainloop - 1)$

Condition III:

$$(\forall t, 0 \leq t \leq Duration, \neg EObserve(B, g, e, t))$$

5.40: Messages implemented out of order

Condition I:

$$\begin{aligned} &Active(B, g) \wedge NCmsgs[B] > 0 \\ &\exists m, 1 \leq m \leq NCmsgs[B], Cmsgs[B, m].Dest = g \wedge \\ &RecT(B, g, m) = Mainloop \end{aligned}$$

Condition II:

$$\begin{aligned} &(\exists n, 1 \leq n \leq NCmsgs[B], m \neq n \wedge Cmsgs[B, n].Dest = g \wedge \\ &RecT(B, g, n) \leq Mainloop \wedge \neg Mimp(B, g, n, Mainloop) \wedge \\ &Cmsgs[B, n].Priority = Cmsgs[B, m].Priority) \vee \\ &(\exists f, Active(B, f), Army[B, f].Report = g \wedge Army[B, f].Priority = Cmsgs[B, m].Priority \wedge \\ &\exists t, Mainloop - RepT(B, f, g) - RecDelay(B, g, Mainloop - Army[B, g].ProcDelay) \\ &- Army[B, g].ProcDelay \\ &< t \leq Mainloop - RepT(B, f, g) - RecDelay(B, g, Mainloop - Army[B, g].ProcDelay), \\ &SomeObserve(B, f, t)) \end{aligned}$$

Condition III: True

Failure Regions in Version 6

6.1: Reversed Parameters in UpdatLOSList

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &BigEnough(B, g, j, e, k, Mainloop) \wedge Params.SampleRate > 2 \end{aligned}$$

Condition II:

$$\begin{aligned} &X_{B,g,j}(Mainloop - 1) \neq X_{\neg B,e,k}(Mainloop - 1) \vee \\ &Y_{B,g,j}(Mainloop - 1) \neq Y_{\neg B,e,k}(Mainloop - 1) \end{aligned}$$

Condition III:

$$\begin{aligned} &(\neg Clear(B, g, j, e, k, Mainloop)) \wedge Obvious(B, g, j, e, k, Mainloop) \wedge \\ &(\forall t, 0 \leq t \leq Duration, EObserve(B, g, e, t)) \end{aligned}$$

6.2: No check on send time for commands of equal priority

Condition I:

$$\begin{aligned} &Active(B, g) \wedge NCmsgs[B] > 0 \wedge NumProcess(B, g, Mainloop) > 0 \wedge \\ &\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Mainloop) \wedge \\ &\neg Mimp(B, g, m, Mainloop - 1) \wedge \\ &\exists n, 1 \leq n \leq NCmsgs[B], m \neq n \wedge Mimp(B, g, n, Mainloop) \wedge \\ &\neg Mimp(B, g, n, Mainloop - 1) \end{aligned}$$

Condition II:

$$\begin{aligned} &m < n \wedge Cmsgs[B, m].Time > Cmsgs[B, n].Time \wedge \\ &Cmsgs[B, m].Priority = Cmsgs[B, n].Priority \end{aligned}$$

Condition III: $Cmsgs[B, m].msg \neq Cmsgs[B, n].msg$

6.3: Improper calculation of LOS list point separation

Condition I:

$$\begin{aligned}
 &Active(B, g) \wedge Active(\neg B, e) \wedge \\
 &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\
 &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\
 &BigEnough(B, g, j, e, k, Mainloop) \wedge Params.SampleRate > 2
 \end{aligned}$$

Condition II:

$$\begin{aligned}
 &\exists i, i \in \{True, False\}, \\
 &xgj = x_{B,g,j}(Mainloop - 1) \wedge ygj = y_{B,g,j}(Mainloop - 1) \wedge \\
 &xek = x_{\neg B,e,k}(Mainloop - 1) \wedge yek = y_{\neg B,e,k}(Mainloop - 1) \wedge \\
 &i = (\forall a, a', c, c', z, z', a = \lfloor \frac{xgj}{Params.XDelta} \rfloor \wedge a' = \lfloor \frac{xek}{Params.XDelta} \rfloor \wedge \\
 &c = \lfloor \frac{ygj}{Params.YDelta} \rfloor \wedge c' = \lfloor \frac{yek}{Params.YDelta} \rfloor \wedge \\
 &z = Alt(a, c, xgj, ygj) \wedge z' = Alt(a', c', xek, yek) \wedge \\
 &(\forall n, 1 \leq n < Params.SampleRate - 1, \\
 &(\exists r, p, q, r = \frac{n}{Params.SampleRate}, p = \lfloor \frac{xgj + r \times (xek - xgj)}{Params.XDelta} \rfloor, q = \lfloor \frac{ygj + r \times (yek - ygj)}{Params.YDelta} \rfloor, \\
 &(z + r \times (z' - z)) > Alt(p, q, xgj + r \times (xek - xgj), ygj + r \times (yek - ygj))))))
 \end{aligned}$$

Condition III:

$$\begin{aligned}
 &(((\neg i) \wedge Clear(B, g, j, e, k, Mainloop)) \vee (i \wedge \neg Clear(B, g, j, e, k, Mainloop))) \wedge \\
 &Obvious(B, g, j, e, k, Mainloop) \wedge \\
 &(\forall t, 0 \leq t \leq Duration, t \neq Mainloop \rightarrow \neg EObserve(B, g, e, t))
 \end{aligned}$$

6.4: Program infinite loops when Duration=0

Condition I: True

Condition II: Duration = 0

Condition III: True

6.5: Improper calculation of Available Weapons

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Params.NumWTypes > 0 \wedge \\ &\exists w, 1 \leq w \leq Params.NumWTypes, NumWeapon(B, g, w, Mainloop) > 0 \wedge \\ &\exists i, 1 \leq i \leq NumWeapon(B, g, w, Mainloop), \\ &(ax_{B,g,w,i}(Mainloop) \neq \infty \vee ay_{B,g,w,i}(Mainloop) \neq \infty) \end{aligned}$$

Condition II: True

Condition III:

$$\begin{aligned} &\exists e, Active(\neg B, e), \\ &(\forall t, 0 \leq t < Mainloop, \neg EObserve(B, g, e, t)) \wedge EObserve(B, g, e, Mainloop) \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &InRange(B, g, w, e, k, Mainloop) \wedge \\ &(\forall w', 1 \leq w' \leq Params.NumWTypes, w' \neq w \rightarrow \\ &(\neg InRange(B, g, w', e, k, Mainloop) \vee NumWeapon(B, g, w', Mainloop) \leq 0)) \end{aligned}$$

6.6: Divide by Zero when assigning target coordinates

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Params.NumWTypes > 0 \wedge \\ &EObserve(B, g, e, Mainloop - 1) \end{aligned}$$

Condition II: $NumWeapon(B, g, 1, Mainloop) \leq 0$

Condition III: True

6.7: Non-reinitialized pointer in SufferAttrition

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Params.NumWTypes > 0 \wedge Mainloop > 2 \wedge \\ &\exists i, 1 \leq i \leq Params.NumWTypes, Army[B, g].Weapon[i].UseLimit > 0 \wedge \\ &NumWeapon(B, g, i, Mainloop) > 0 \wedge Army[B, g].Weapon[i].FireRate > 0 \wedge \\ &Army[B, g].WeapPriority[e, i] > 0 \wedge \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop - 2) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop - 2) > 0 \wedge \\ &Observe(B, g, j, e, k, Mainloop - 2) \wedge InRange(B, g, w, e, k, Mainloop - 2) \end{aligned}$$

Condition II: True

Condition III: True

6.8: Undefined pointer reference in SufferAttrition

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Params.NumWTypes > 0 \wedge Mainloop > 2 \wedge \\ &\exists i, 1 \leq i \leq Params.NumWTypes, Army[B, g].Weapon[i].UseLimit > 0 \wedge \\ &NumWeapon(B, g, i, Mainloop) > 0 \wedge Army[B, g].Weapon[i].FireRate > 0 \wedge \\ &Army[B, g].WeapPriority[e, i] > 0 \wedge \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop - 1) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop - 1) > 0 \wedge \\ &Observe(B, g, j, e, k, Mainloop - 1) \wedge InRange(B, g, w, e, k, Mainloop - 1) \end{aligned}$$

Condition II: True

Condition III: True

6.9: No initialization of Observations.NumObserved

Condition I: $Active(B, g) \wedge Active(\neg B, e) \wedge EObserved(B, g, e, 1)$

Condition II: True

Condition II:

$$\begin{aligned} &Params.NumWTypes > 0 \wedge \\ &\exists w, 1 \leq w \leq Params.NumWTypes, Army[B, g].WeapPriority[e, w] > 0 \wedge \\ &NumWeapon(B, g, w, 2) > 0 \wedge Army[B, g].Weapon[w].FireRate > 0 \wedge \\ &Army[B, g].Weapon[w].UseLimit > 0 \wedge \\ &Army[B, g].Weapon[w].Range > \sqrt{(X_{B,g}(1) - X_{\neg B,e}(1))^2 + (Y_{B,g}(1) - Y_{\neg B,e}(1))^2} \end{aligned}$$

6.11: Command message improperly dropped from Commands-Finished list

Condition I:

$$\begin{aligned} &Active(B, g) \wedge NCmsgs[B] > 0 \wedge \\ &\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Mainloop) \wedge \neg Mimp(B, g, m, Mainloop - 1) \wedge \\ &\exists n, 1 \leq n \leq NCmsgs[B], m < n \wedge Mimp(B, g, n, Mainloop) \wedge \\ &\neg Mimp(B, g, n, Mainloop - 1) \wedge Cmsgs[B, m].Priority \geq Cmsgs[B, n].Priority \end{aligned}$$

Condition II: True

Condition III: True

6.12: Substitution of ComJamEff for ComJamRadius

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge NumRec(B, g, Mainloop) > 0 \wedge \\ &(NCmsgs[B] > 0 \wedge \exists m, 1 \leq m \leq NCmsgs[B], RecT(B, g, m) = Mainloop) \vee \\ &(Active(B, f) \wedge Army[B, f].Report = g \wedge NumSend(B, f, Mainloop) > 0 \wedge \\ &SomeObserve(B, f, Mainloop - RepT(B, f, g)) \wedge Army[\neg B, e].ComJamEff > 0 \end{aligned}$$

Condition II: $Army[\neg B, e].ComJamEff \neq Army[\neg B, e].ComJamRadius$

Condition III: True

6.13: Command messages implemented in destroyed battalions

Condition I:

$$\begin{aligned} &\exists B, B \in \{True, False\}, NArmy[B] > 0 \wedge NCmsgs[B] > 0 \wedge \\ &\exists Mainloop, 1 \leq Mainloop < Duration, \\ &\exists m, 1 \leq m \leq NCmsgs[B], 1 \leq Cmsgs[B, m].Dest \leq NArmy[B] \wedge \\ &s(B, Cmsgs[B, m].Dest, Cmsgs[B, m].Time) > 0 \wedge \\ &Mimp(B, Cmsgs[B, m].Dest, m, Mainloop) \wedge \\ &\neg Mimp(B, Cmsgs[B, m].Dest, m, Mainloop - 1) \end{aligned}$$

Condition II: $s(B, Cmsgs[B, m].Dest, Mainloop) \leq 0$

Condition III: $Cmsgs[B, m].msg \neq Army[B, Cmsgs[B, m].Dest]$

6.14: InOwnObsv in UpdateLL is not initialized

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Active(B, f) \wedge Army[B, f].Report = g \wedge \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &Observe(B, g, j, e, k, Mainloop) \wedge \\ &\exists t, 0 \leq t = Mainloop - RepT(B, f, g) - Army[B, g].ProcDelay - \\ &\quad \frac{Army[B, g].RecRate}{NumRec(B, g, Mainloop - Army[B, g].ProcDelay)}, \\ &\exists j', 1 \leq j' \leq Army[B, f].Squadrons, Endurance(B, f, j', t) > 0 \wedge \\ &Observe(B, f, j', e, k, t) \end{aligned}$$

Condition II: True

Condition III: $X_{\neg B, e, k}(Mainloop) \neq X_{\neg B, e, k}(t) \vee Y_{\neg B, e, k}(Mainloop) \neq Y_{\neg B, e, k}(t)$

6.15: NewArmy not updated after command message

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Mainloop = Duration \wedge NCmsgs[B] > 0 \wedge \\ &\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Duration) \wedge \neg Mimp(B, g, m, Duration - 1) \end{aligned}$$

Condition II: $Cmsgs[B, m].msg \neq Army[B, g]$

Condition III: True

6.16: Observe blocked when Params.SampleRate = 2

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &BigEnough(B, g, j, e, k, Mainloop) \end{aligned}$$

Condition II: $Params.SampleRate = 2$

Condition III: True

6.17: NumWeapons>0 when Army.Weapon.FireRate=0

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Params.NumWTypes > 0 \wedge \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &Observe(B, g, j, e, k, Mainloop - 1) \wedge \\ &\exists w, 1 \leq w \leq Params.NumWTypes, NumWeapon(B, g, w, Mainloop) > 0 \wedge \\ &InRange(B, g, w, e, k, Mainloop) \wedge Army[B, g].Weapon[w].UseLimit > 0 \wedge \\ &Army[B, g].WeapPriority[e, w] > 0 \end{aligned}$$

Condition II: $Army[B, g].Weapon[w].FireRate = 0$

Condition III:

$$\begin{aligned} &\nexists t, 0 < t \leq Duration, \\ &\exists j', 1 \leq j' \leq Army[B, g].Squadrons, Endurance(B, g, j', t) > 0 \wedge \\ &\exists k', 1 \leq k' \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k', t) > 0 \wedge \\ &Observe(B, g, j', e, k', t - 1) \wedge \\ &\exists w', 1 \leq w' \leq Params.NumWTypes, NumWeapon(B, g, w', t) > 0 \wedge \\ &InRange(B, g, w', e, k', t) \wedge Army[B, g].Weapon[w'].UseLimit > 0 \wedge \\ &Army[B, g].WeapPriority[e, w'] > 0 \wedge Army[B, g].Weapon[w'].FireRate > 0 \end{aligned}$$

6.18: Report messages blocked by bad condition

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Active(B, f) \wedge Army[B, f].Report = g \wedge \\ &\exists t, 0 < t = Mainloop - RepT(B, f, g) - Army[B, g].ProcDelay - \\ &\quad \frac{Army[B, g].RecRate}{NumRec(B, g, Mainloop - Army[B, g].ProcDelay)}, \\ &EObserve(B, f, e, t - 1) \wedge NumSend(B, f, t) > 0 \wedge Army[B, f].ObsXpire > 0 \end{aligned}$$

Condition II: True

Condition III: $\nexists t', 0 \leq t' \leq Duration, EObserve(B, g, e, t')$

6.20: Destroyed battalions not initialized

Condition I: True

Condition II:

$$\begin{aligned} &\exists B, B \in \{True, False\}, NArmy[B] > 0 \wedge \\ &\exists g, 1 \leq g \leq NArmy[B], Army[B, g].Squadrons \leq 0 \end{aligned}$$

Condition II: True

6.23: UseLimit not checked until after first weapon use

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Params.NumWTypes > 0 \wedge \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &Observe(B, g, j, e, k, Mainloop - 1) \wedge \\ &\exists w, 1 \leq w \leq Params.NumWTypes, NumWeapon(B, g, w, Mainloop) > 0 \wedge \\ &InRange(B, g, w, e, k, Mainloop) \wedge Army[B, g].Weapon[w].FireRate > 0 \wedge \\ &Army[B, g].WeapPriority[e, w] > 0 \end{aligned}$$

Condition II: $Army[B, g].Weapon[w].UseLimit = 0$

Condition III:

$$\begin{aligned} &\nexists t, 0 < t \leq Duration, \\ &\exists j', 1 \leq j' \leq Army[B, g].Squadrons, Endurance(B, g, j', t) > 0 \wedge \\ &\exists k', 1 \leq k' \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k', t) > 0 \wedge \\ &Observe(B, g, j', e, k', t - 1) \wedge \\ &\exists w', 1 \leq w' \leq Params.NumWTypes, NumWeapon(B, g, w', t) > 0 \wedge \\ &InRange(B, g, w', e, k', t) \wedge Army[B, g].Weapon[w'].UseLimit > 0 \wedge \\ &Army[B, g].WeapPriority[e, w'] > 0 \wedge Army[B, g].Weapon[w'].FireRate > 0 \end{aligned}$$

6.24: Available processors don't include just finished commands and reports

Condition I:

$$\begin{aligned}
 &Active(B, g) \wedge ((NCmsgs[B] > 0 \wedge \\
 &\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Mainloop) \wedge \\
 &\neg Mimp(B, g, m, Mainloop - 1)) \vee \\
 &(Active(B, f) \wedge Active(\neg B, e) \wedge Army[B, f].Report = g \wedge \\
 &\exists t, 0 < t = Mainloop - RepT(B, f, g) - Army[B, g].ProcDelay - \\
 &\quad \frac{Army[B, g].RecRate}{NumRec(B, g, Mainloop - Army[B, g].ProcDelay)}, \\
 &EObserve(B, f, e, t - 1) \wedge NumSend(B, f, t) > 0))
 \end{aligned}$$

Condition II:

$$\begin{aligned}
 &CmdSum(B, g, -1, Mainloop) + ReptSum(B, g, -1, Mainloop) \\
 &> NumProcess(B, g, Mainloop)
 \end{aligned}$$

Condition III: True

Failure Regions in Version 7

7.1: VisableSquad return upredictable on destroyed squadrons

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$(\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) \leq 0) \vee \\ (\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) \leq 0)$$

Condition III: $\nexists t, 0 \leq t \leq Duration, EObserve(B, g, e, t)$

7.2: Division by zero NumWeapon in InflictAttrition

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge Params.NumWTypes > 0 \wedge \\ \exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop - 2) > 0 \wedge \\ (\exists j, 1 \leq j \leq Army[B, e].Squadrons, Endurance(B, g, j, Mainloop - 2) > 0 \wedge \\ Observe(B, g, j, e, k, Mainloop - 2)) \wedge \\ \exists w, 1 \leq w \leq Params.NumWTypes, InRange(B, g, w, e, k, Mainloop - 1) \wedge \\ Army[B, g].WeapPriority[e, w] > 0 \wedge NumWeapon(B, g, w, Mainloop - 1) > 0 \wedge \\ Army[B, g].Weapon[w].FireRate > 0 \wedge Army[B, g].Weapon[w].UseLimit > 0$$

Condition II: $NumWeapon(B, g, w, Mainloop) = 0$

Condition III: True

7.3: Division by zero NumObservArray in InflictAttrition

Condition I:

$$Active(B, g) \wedge Active(\neg B, e) \wedge Params.NumWTypes > 0 \wedge \\ \exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop - 2) > 0 \wedge \\ (\exists j, 1 \leq j \leq Army[B, e].Squadrons, Endurance(B, g, j, Mainloop - 2) > 0 \wedge \\ Observe(B, g, j, e, k, Mainloop - 2)) \wedge \\ \exists w, 1 \leq w \leq Params.NumWTypes, InRange(B, g, w, e, k, Mainloop - 1) \wedge \\ Army[B, g].WeapPriority[e, w] > 0 \wedge NumWeapon(B, g, w, Mainloop) > 0 \wedge \\ Army[B, g].Weapon[w].FireRate > 0 \wedge Army[B, g].Weapon[w].UseLimit > 0$$

Condition II: $\neg EObserve(B, g, e, Mainloop)$

Condition III: True

7.4: Bad count of busy command processing squadrons

Condition I:

$$\begin{aligned} &Active(B, g) \wedge ((NCmsgs[B] > 0 \wedge \\ &\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Mainloop) \wedge \\ &\neg Mimp(B, g, m, Mainloop - 1)) \vee \\ &(Active(B, f) \wedge Active(\neg B, e) \wedge Army[B, f].Report = g \wedge \\ &\exists t, 0 < t = Mainloop - ReptT(B, f, g) - Army[B, g].ProcDelay - \\ &\quad \frac{Army[B, g].RecRate}{NumRec(B, g, Mainloop - Army[B, g].ProcDelay)}, \\ &EObserve(B, f, e, t - 1) \wedge NumSend(B, f, t) > 0)) \end{aligned}$$

Condition II:

$$\begin{aligned} &CmdSum(B, g, -1, Mainloop) + ReptSum(B, g, -1, Mainloop) \\ &> NumProcess(B, g, Mainloop) \end{aligned}$$

Condition III: True

7.5: Bad check in Observation

Condition I: $Active(B, g) \wedge Active(\neg B, e) \wedge EObserve(B, g, e, Mainloop)$

Condition II: $Active(B, f) \wedge f > g \wedge EObserve(B, f, e, Mainloop)$

Condition III:

$$\begin{aligned} &\nexists t, 1 \leq t \leq Duration, EObserve(B, f, e, t) \wedge \\ &\forall f', 1 \leq f' < f, \neg EObserve(B, f', e, t) \end{aligned}$$

7.6: Bad condition on NArmy check

Condition I: $Duration > 0$

Condition II: $\exists B, B \in \{True, False\}, NArmy[B] = 0$

Condition III: True

7.7: Improperly rejected ObsXpire=0

Condition I: $Duration > 0 \wedge \exists B, B \in \{True, False\}, NArmy[B] > 0$

Condition II: $\exists g, 1 \leq g \leq NArmy[B], Army[B, g].ObsXpire = 0$

Condition III: True

7.8: Improperly rejected ProcDelay=0

Condition I: $Duration > 0 \wedge \exists B, B \in \{True, False\}, NArmy[B] > 0$

Condition II: $\exists g, 1 \leq g \leq NArmy[B], Army[B, g].ProcDelay = 0$

Condition III: True

7.9: No report communication

Condition I:

$$\begin{aligned}
 &Active(B, g) \wedge Active(\neg B, e) \wedge Active(B, f) \wedge Army[B, f].Report = g \wedge \\
 &\exists t, 0 < t = Mainloop - RepT(B, f, g) - Army[B, g].ProcDelay - \\
 &\quad \frac{Army[B, g].RecRate}{NumReceive(B, g, Mainloop - Army[B, g].ProcDelay)}, \\
 &EObserve(B, f, e, t - 1) \wedge NumSend(B, f, t) > 0 \wedge Army[B, f].ObsXpire > 0
 \end{aligned}$$

Condition II: True

Condition III: $\nexists t', 0 \leq t' \leq Duration, EObserve(B, g, e, t')$

7.10: Misplaced reinitialization of variable in Observation

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$\begin{aligned}
 &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\
 &(\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\
 &Observe(B, g, j, e, k, Mainloop)) \wedge \\
 &\exists k', k < k' \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k', Mainloop) > 0 \wedge \\
 &(\exists j', 1 \leq j' \leq Army[B, g].Squadrons, Endurance(B, g, j', Mainloop) > 0 \wedge \\
 &Observe(B, g, j', e, k', Mainloop))
 \end{aligned}$$

Condition III:

$$\begin{aligned}
 &Params.NumWTypes > 0 \wedge Mainloop + 1 < Duration \wedge \\
 &\exists w, 1 \leq w \leq Params.NumWTypes, NumWeapon(B, g, w, Mainloop + 1) > 1 \wedge \\
 &Army[B, g].Weapon[w].FireRate > 0 \wedge Army[B, g].Weapon[w].UseLimit > 0 \wedge \\
 &Army[B, g].WeapPriority[e, w] > 1 \wedge \\
 &\frac{Endurance(\neg B, e, k, Mainloop + 1)}{2} \leq Army[B, g].Weapon[w].Damage + Army[\neg B, e].Wear \\
 &< Endurance(\neg B, e, k, Mainloop + 1)
 \end{aligned}$$

7.11: Segmentation Violation if battalion leaves terrain grid

Condition I: $(Duration > 0)$

Condition II:

$$\begin{aligned}
 &\exists B, g, Active(B, g) \wedge \\
 &(X_{B, g} < 0 \vee Y_{B, g} < 0)
 \end{aligned}$$

Condition III: True

7.12: Restoration>0 after FixSuppl=0

Condition I: $Active(B, g) \wedge NumCas(B, g, Mainloop - 1) > 0$

Condition II: $Suppl(B, g, Mainloop - 2) < 0$

Condition III:

$$\exists j, 1 \leq j \leq Army[B, g].Squadrons, \\ \frac{Army[B, g].Endurance[j]}{2} < Endurance(B, g, j, Mainloop - 1) - \frac{Suppl(B, g, Mainloop - 2)}{NumCas(B, g, Mainloop - 1)}$$

7.13: Wrong variable on loop in Observation

Condition I: $Active(B, g)$

Condition II: $NArmy[B] \neq NArmy[\neg B]$

Condition III:

$$(NArmy[B] > NArmy[\neg B]) \vee \\ (NArmy[B] < NArmy[\neg B]) \wedge \\ \exists e, NArmy[B] < e \leq NArmy[\neg B], Active(\neg B, e) \wedge \\ EObserve(B, g, e, Mainloop))$$

7.14: Command with 0 squadrons doesn't destroy battalion

Condition I:

$$Active(B, g) \wedge NCmsgs[B] > 0 \wedge \\ \exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Mainloop) \wedge \neg Mimp(B, g, m, Mainloop - 1)$$

Condition II: $Cmsgs[B, m].msg.Squadrons = 0$

Condition III: True

7.15: NumWeaponToUse not initialized

Condition I: $Active(B, g) \wedge Active(\neg B, e) \wedge EObserve(B, g, e, Mainloop)$

Condition II: True

Condition III: $Mainloop < Duration - 1$

7.16: Does not reject Army.NumFixers > Army.Squadrons

Condition I: $(Duration \geq 0)$

Condition II:

$$(\exists B, B \in \{1 \dots NArmy[true]\}, \\ Army[true, B].NumFixers > Army[true, B].Squadrons) \vee \\ (\exists B, B \in \{1 \dots NArmy[false]\}, \\ Army[false, B].NumFixers > Army[false, B].Squadrons)$$

Condition III: True

7.17: Does not reject $\text{Army.NumJammers} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumJammers} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumJammers} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

7.18: Does not reject $\text{Army.NumProcess} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumProcess} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumProcess} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

7.19: Does not reject $\text{Army.NumReceive} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumReceive} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumReceive} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

7.20: Does not reject $\text{Army.NumSend} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumSend} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumSend} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

7.21: Does not reject Cmsgs.msg.NumFixers > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad & B \in \{\text{true}, \text{false}\}, \\ & (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ & \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumFixers} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

7.22: Does not reject Cmsgs.msg.NumJammers > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad & B \in \{\text{true}, \text{false}\}, \\ & (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ & \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumJammers} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

7.23: Does not reject Cmsgs.msg.NumProcess > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad & B \in \{\text{true}, \text{false}\}, \\ & (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ & \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumProcess} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

7.24: Does not reject Cmsgs.msg.NumReceive > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad B \in \{\text{true}, \text{false}\}, \\ (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumReceive} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

7.25: Does not reject Cmsgs.msg.NumSend > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad B \in \{\text{true}, \text{false}\}, \\ (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumSend} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

7.27: Divide by zero KF in CalcNumWeapToUse

Condition I:

$$\begin{aligned} & \text{Active}(B, g) \wedge \text{Active}(\neg B, e) \wedge \text{Params}.\text{NumWTypes} > 0 \wedge \\ & \exists w, 1 \leq w \leq \text{Params}.\text{NumWtypes}, \text{NumWeapon}(B, g, w, \text{Mainloop}) > 0 \wedge \\ & \exists j, 1 \leq j \leq \text{Army}[B, g].\text{Squadrons}, \text{Endurance}(B, g, j, \text{Mainloop}) > 0 \wedge \\ & \exists k, 1 \leq k \leq \text{Army}[\neg B, e].\text{Squadrons}, \text{Endurance}(\neg B, e, k, \text{Mainloop}) > 0 \wedge \\ & \text{Observe}(B, g, j, e, k, \text{Mainloop} - 1) \wedge \text{InRange}(B, g, w, e, k, \text{Mainloop} - 1) \end{aligned}$$

Condition II: $\text{Army}[B, g].\text{Weapon}[w].\text{FireRate} = 0$

Condition III: True

7.28: Number Variables exceed initial values

Condition I: $Active(B, g) \wedge NumCas(B, g, Mainloop - 1) > 0$

Condition II: $s(B, g, Mainloop) < NumCas(B, g, Mainloop - 1) - NumCas(B, g, Mainloop)$

Condition III: True

7.29: Double increments of Weapon and Target index

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge Params.NumWTypes > 0 \wedge Mainloop > 2 \wedge$

$\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge$

$\exists k, 1 < k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge$

$\exists w, 1 \leq w \leq Params.NumWTypes, NumWeapon(B, g, w, Mainloop) > 1 \wedge$

$Observe(B, g, j, e, k, Mainloop - 2) \wedge InRange(B, g, w, e, k, Mainloop - 1) \wedge$

$Army[B, g].WeapPriority[e, w] > 1 \wedge Army[B, g].Weapon[w].UseLimit > 0 \wedge$

$Army[B, g].Weapon[w].FireRate > 0$

Condition II:

$\exists j', 1 \leq j' \leq Army[B, g].Squadrons, Endurance(B, g, j', Mainloop - 2) > 0 \wedge$

$Observe(B, g, j', e, k - 1, Mainloop - 2)$

Condition III: $Army[B, g].Weapon[w].Damage > 0$

7.32: Numeric Precision fault in Series

Condition I:

$$\begin{aligned}
 &Active(B, g) \wedge Active(\neg B, e) \wedge Params.SampleRate > 2\Delta \\
 &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0\Delta \\
 &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0\Delta \\
 &BigEnough(B, g, j, e, k, Mainloop)
 \end{aligned}$$

Condition II:

$$\log_2(Params.SampleRate) \neq \lfloor \log_2(Params.SampleRate) \rfloor$$

Condition III:

$$\begin{aligned}
 &xgj = x_{B,g,j}(Mainloop - 1) \wedge ygj = y_{B,g,j}(Mainloop - 1) \wedge \\
 &xek = x_{\neg B,e,k}(Mainloop - 1) \wedge yek = y_{\neg B,e,k}(Mainloop - 1) \wedge \\
 &(\forall a, a', c, c', z, z', a = \lfloor \frac{xgj}{Params.XDelta} \rfloor \wedge a' = \lfloor \frac{xek}{Params.XDelta} \rfloor \wedge \\
 &\quad c = \lfloor \frac{ygj}{Params.YDelta} \rfloor \wedge c' = \lfloor \frac{yek}{Params.YDelta} \rfloor \wedge \\
 &\quad z = Alt(a, c, xgj, ygj) \wedge z' = Alt(a', c', xek, yek) \wedge \\
 &(\forall n, 1 \leq n < 2^{\lfloor \log_2(Params.SampleRate) \rfloor} - 1, \\
 &\quad (\exists r, p, q, x', y', r = \frac{n}{2^{\lfloor \log_2(Params.SampleRate) \rfloor} - 1}, \\
 &\quad x' = xgj + r \times (xek - xgj), y' = ygj + r \times (yek - ygj), \\
 &\quad p = \lfloor \frac{x'}{Params.XDelta} \rfloor, q = \lfloor \frac{y'}{Params.YDelta} \rfloor, \\
 &\quad (z + r \times (z' - z)) > Alt(p, q, x', y') \\
 &)) \wedge \\
 &((\frac{BI(a', c', xek, yek) - Army[\neg B, e].SquadIntensity[k]}{BI(a', c', xek, yek)} - \\
 &\sum_{n=1}^{2^{\lfloor \log_2(Params.SampleRate) \rfloor}} ((WO(xgj \times \frac{n \times (xek - xgj)}{2^{\lfloor \log_2(Params.SampleRate) \rfloor}}, ygj \times \frac{n \times (yek - ygj)}{2^{\lfloor \log_2(Params.SampleRate) \rfloor}}, Mainloop) \times \\
 &\quad Army[B, g].VWEffect) + \\
 &\quad \sum_{e'=1}^{NArmy[\neg B]} \left\{ \begin{array}{ll} 0 & \text{if } \sqrt{\frac{(x_{\neg B,e'}(Mainloop - 1) - xgj \times \frac{n \times (xek - xgj)}{2^{\lfloor \log_2(Params.SampleRate) \rfloor} - 1})^2 + (y_{\neg B,e'}(Mainloop - 1) - ygj \times \frac{n \times (yek - ygj)}{2^{\lfloor \log_2(Params.SampleRate) \rfloor} - 1})^2}{Army[\neg B, e'].ObsJamRadius}} > Army[\neg B, e'].ObsJamRadius \\ \sqrt{\frac{(x_{\neg B,e'}(Mainloop - 1) - xgj \times \frac{n \times (xek - xgj)}{2^{\lfloor \log_2(Params.SampleRate) \rfloor}})^2 + (y_{\neg B,e'}(Mainloop - 1) - ygj \times \frac{n \times (yek - ygj)}{2^{\lfloor \log_2(Params.SampleRate) \rfloor}})^2}{Army[\neg B, e'].ObsJamRadius}}} & \text{otherwise} \end{array} \right\} \\
 &)) < Army[B, g].ObsMinContrast[j]))
 \end{aligned}$$

7.33: Undefined value when battalion leaves terrain grid

Condition I: $(\text{Duration} > 0)$

Condition II:

$$\begin{aligned} &\exists B, g, \text{Active}(B, g) \wedge \\ &\quad (X_{B,g}(\text{Mainloop}) \geq \text{Params.XDelta} \times \text{MaxTerrain} \vee \\ &\quad Y_{B,g}(\text{Mainloop}) \geq \text{Params.YDelta} \times \text{MaxTerrain}) \end{aligned}$$

Condition III: True

7.35: Invalid expiration of observations

Condition I: $\text{Active}(B, g) \wedge \text{Active}(\neg B, e) \wedge E\text{Observe}(B, g, e, \text{Mainloop})$

Condition II: $\text{Army}[B, g].\text{ObsXpire} < 2$

Condition III:

$$\begin{aligned} &\text{Mainloop} < \text{Duration} - 1 \wedge \text{Params.NumWTypes} > 0 \wedge \\ &\exists w, 1 \leq w \leq \text{Params.NumWTypes}, \text{NumWeapon}(B, g, w, \text{Mainloop} + 1) > 0 \wedge \\ &\text{Army}[B, g].\text{WeapPriority}[e, w] > 0 \wedge \text{Army}[B, g].\text{Weapon}[w].\text{UseLimit} > 0 \wedge \\ &\text{Army}[B, g].\text{Weapon}[w].\text{Range} > 0 \wedge \text{Army}[B, g].\text{Weapon}[w].\text{Damage} > 0 \wedge \\ &\text{Army}[B, g].\text{Weapon}[w].\text{FireRate} > 0 \end{aligned}$$

Failure Regions in Version 8

8.1: Divide by zero in UpdateKA

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Params.NumWTypes > 0 \wedge \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &Observe(B, g, j, e, k, Mainloop) \wedge \\ &\exists w, 1 \leq w \leq Params.NumWTypes, NumWeapon(B, g, w, Mainloop) > 0 \wedge \\ &InRange(B, g, w, e, k, Mainloop) \wedge Army[B, g].Weapon[w].FireRate > 0 \wedge \\ &Army[B, g].WeapPriority[e, w] > 0 \end{aligned}$$

Condition II: $Army[B, g].Weapon[w].UseLimit = 0$

Condition III: True

8.2: Divide by zero in SquadPos

Condition I: $Active(B, g)$

Condition II: $Army[B, g].Grow = 0$

Condition III: True

8.3: No check on send time for equal-priority messages at start of queue

Condition I: $Active(B, g) \wedge NCmsgs[B] > 1$

Condition II:

$$\begin{aligned} &\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Mainloop) \wedge \neg Mimp(B, g, m, Mainloop - 1) \wedge \\ &\exists n, 1 \leq n \leq NCmsgs[B], Mimp(B, g, n, Mainloop) \wedge \neg Mimp(B, g, n, Mainloop - 1) \wedge \\ &Cmsgs[B, m].Priority = Cmsgs[B, n].Priority \wedge Cmsgs[B, m].Time < Cmsgs[B, n].Time \wedge \\ &Cmsgs[B, m].msg \neq Cmsgs[B, n].msg \end{aligned}$$

Condition III:

$$\nexists m', 1 \leq m' \leq NCmsgs[B], Mimp(B, g, m', Duration) \wedge \neg Mimp(B, g, m', Mainloop)$$

8.4: Pointer past end of list in PutQue

Condition I:

$$\begin{aligned} &Active(B, g) \wedge NCmsgs[B] > 1 \wedge \\ &\exists m, 1 \leq m \leq NCmsgs[B], Cmsgs[B, m].Dest = g \wedge \\ &RecT(B, g, m) < Mainloop \wedge \neg Mimp(B, g, m, Mainloop) \wedge \\ &\exists n, 1 \leq n \leq NCmsgs[B], Cmsgs[B, n].Dest = g \wedge \\ &RecT(B, g, n) = Mainloop \wedge Cmsgs[B, m].Priority = Cmsgs[B, n].Priority \end{aligned}$$

Condition II:

$$\begin{aligned} &\nexists m', 1 \leq m' \leq NCmsgs[B], Cmsgs[B, m'].Dest = g \wedge \\ &m' \neq m \wedge m' \neq n \wedge RecT(B, g, m') \leq Mainloop \wedge \\ &\neg Mimp(B, g, m', Mainloop) \end{aligned}$$

Condition III: True

8.5: Infinite loop in InsertMsg

Condition I:

$$\begin{aligned} &Active(B, g) \wedge NCmsgs[B] > 1 \wedge \\ &\exists m, 1 \leq m \leq NCmsgs[B], Cmsgs[B, m].Dest = g \wedge \\ &RecT(B, g, m) < Mainloop \wedge \neg Mimp(B, g, m, Mainloop) \wedge \\ &\exists n, 1 \leq n \leq NCmsgs[B], Cmsgs[B, n].Dest = g \wedge \\ &RecT(B, g, n) = Mainloop \end{aligned}$$

Condition II: $Cmsgs[B, m].Priority \leq Cmsgs[B, n].Priority$

Condition III: True

8.6: No check on send time for equal-priority messages in middle of queue

Condition I: $Active(B, g) \wedge NCmsgs[B] > 2$

Condition II:

$$\begin{aligned} &\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Mainloop) \wedge \\ &\neg Mimp(B, g, m, Mainloop - 1) \wedge \\ &\exists n, 1 \leq n \leq NCmsgs[B], Mimp(B, g, n, Mainloop) \wedge \\ &\neg Mimp(B, g, n, Mainloop - 1) \wedge \\ &\exists m', 1 \leq m' \leq NCmsgs[B], Mimp(B, g, m', Mainloop) \wedge \\ &\neg Mimp(B, g, m', Mainloop - 1) \wedge \\ &Cmsgs[B, m'].Priority > Cmsgs[B, m].Priority \wedge Cmsgs[B, m].Priority = Cmsgs[B, n].Priority \wedge \\ &Cmsgs[B, m].Time < Cmsgs[B, n].Time \wedge Cmsgs[B, m].msg \neq Cmsgs[B, n].msg \end{aligned}$$

Condition III:

$$\nexists m', 1 \leq m' \leq NCmsgs[B], Mimp(B, g, m', Duration) \wedge \neg Mimp(B, g, m', Mainloop)$$

8.7: NC not zeroed on receipt of command message

Condition I:

$$Active(B, g) \wedge NCmsgs[B] > 0 \wedge$$

$$\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Mainloop) \wedge \neg Mimp(B, g, m, Mainloop - 1)$$

Condition II: $NumCas(B, g, Mainloop) > 0$

Condition III:

$$\nexists n, 1 \leq n \leq NCmsgs[B], Mimp(B, g, n, Duration) \wedge \neg Mimp(B, g, n, Mainloop)$$

8.8: Segmentation violation when squadron is off terrain grid and

8.10: Infinite loop in CalcBI

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge$$

$$(X_{B,g,j}(Mainloop) < 0 \vee Y_{B,g,j}(Mainloop) < 0)$$

Condition III: True

8.9: Observation blocked if first squadron destroyed

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II: $Endurance(B, g, 1, Mainloop) \leq 0$

Condition III:

$$\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge$$

$$\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge$$

$$Observe(B, g, j, e, k, Mainloop) \wedge$$

$$(\nexists t, 0 \leq t \leq Mainloop, EObserve(B, g, e, t)) \wedge$$

$$(\nexists f, Active(B, f), Army[B, f].Report = g \wedge$$

$$\exists t, 0 \leq t = Mainloop - RepT(B, f, g) - Army[B, g].ProcDelay -$$

$$\frac{Army[B, g].RecRate}{NumRec(B, g, Mainloop - Army[B, g].ProcDelay)},$$

$$EObserve(B, f, e, t)$$

8.11: Excessive length loop in CalcBI

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$\begin{aligned} &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &(X_{B,g,j}(Mainloop) > MaxTerrain \times Params.XDelta \vee \\ &Y_{B,g,j}(Mainloop) > MaxTerrain \times Params.YDelta) \end{aligned}$$

Condition III: True

8.12: No check if $RA \leq 0$

Condition I:

$$\begin{aligned} &Active(B, g) \wedge ((NCmsgs[B] > 0 \wedge \\ &\exists m, 1 \leq m \leq NCmsgs[B], Cmsgs[B, m].Dest = g \wedge RecT(B, g, m) = Mainloop) \vee \\ &(Active(B, f) \wedge Active(\neg B, e) \wedge Army[B, f].Report = g \wedge \\ &EObserve(B, f, e, Mainloop - RepT(B, f, g)))) \end{aligned}$$

Condition II: $NumRec(B, g, Mainloop) \leq ComJam(B, g, Mainloop)$

Condition III: True

8.13: Always engaged if observation is within range

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Params.NumWTypes > 0 \wedge \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &Observe(B, g, j, e, k, Mainloop) \end{aligned}$$

Condition II:

$$\begin{aligned} &\forall w, 1 \leq w \leq Params.NumWTypes, InRange(B, g, w, e, k, Mainloop) \rightarrow \\ &(NumWeapon(B, g, w, Mainloop) \leq 0 \vee Army[B, g].WeapPriority[e, w] \leq 0 \vee \\ &Army[B, g].Weapon[w].FireRate \leq 0 \vee Army[B, g].Weapon[w].UseLimit \leq 0) \end{aligned}$$

Condition III: True

8.14: Divide by zero in OJ calculation

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge Params.SampleRate > 2 \wedge \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &BigEnough(B, g, j, e, k, Mainloop) \wedge Clear(B, g, j, e, k, Mainloop) \end{aligned}$$

Condition II: $\exists e', Active(\neg B, e'), Army[\neg B, e'].ObJamRadius = 0$

Condition III: True

8.15: Version does not observe when Params.SampleRate = 2

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &BigEnough(B, g, j, e, k, Mainloop) \end{aligned}$$

Condition II: Params.SampleRate = 2

Condition III: True

8.18: Destroyed battalions still move

and

8.35: Velocity undefined if battalion destroyed

Condition I: $Duration > 2 \wedge \exists B, B \in \{True, False\}, NArmy[B] > 0$

Condition II:

$$\exists g, 1 \leq g \leq NArmy[B], \exists t, 0 \leq t < Duration - 1, s(B, g, t) = 0$$

Condition III: True

8.19: Version observes when Params.SampleRate < 2

and

8.39: Divide by zero in FindPoints

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &BigEnough(B, g, j, e, k, Mainloop) \end{aligned}$$

Condition II: Params.SampleRate < 2

Condition III: True

8.23: Use of 0 as flag conflicts with position in width

Condition I: $Active(B, g)$

Condition II:

$$\begin{aligned} &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &X_{B, g, j}(Mainloop) < 0 \end{aligned}$$

Condition III: $Mainloop = Duration - 1$

8.25: Does not reject $\text{Army.NumFixers} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumFixers} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumFixers} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

8.26: Does not reject $\text{Army.NumJammers} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumJammers} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumJammers} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

8.27: Does not reject $\text{Army.NumProcess} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumProcess} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumProcess} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

8.28: Does not reject $\text{Army.NumReceive} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots N\text{Army}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumReceive} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots N\text{Army}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumReceive} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

8.29: Does not reject $\text{Army.NumSend} > \text{Army.Squadrons}$

Condition I: $(\text{Duration} \geq 0)$

Condition II:

$$\begin{aligned} &(\exists B, B \in \{1 \dots \text{NArmy}[\text{true}]\}, \\ &\quad \text{Army}[\text{true}, B].\text{NumSend} > \text{Army}[\text{true}, B].\text{Squadrons}) \vee \\ &(\exists B, B \in \{1 \dots \text{NArmy}[\text{false}]\}, \\ &\quad \text{Army}[\text{false}, B].\text{NumSend} > \text{Army}[\text{false}, B].\text{Squadrons}) \end{aligned}$$

Condition III: True

8.30: Does not reject $\text{Cmsgs.msg.NumFixers} > \text{Cmsgs.msg.Squadrons}$

Condition I:

$$\begin{aligned} &\exists B, \quad B \in \{\text{true}, \text{false}\}, \\ &\quad (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ &\quad \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg.NumFixers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$$

Condition III: True

8.31: Does not reject $\text{Cmsgs.msg.NumJammers} > \text{Cmsgs.msg.Squadrons}$

Condition I:

$$\begin{aligned} &\exists B, \quad B \in \{\text{true}, \text{false}\}, \\ &\quad (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ &\quad \quad (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg.NumJammers} > \text{Cmsgs}[B, m].\text{msg.Squadrons}$$

Condition III: True

8.32: Does not reject Cmsgs.msg.NumProcess > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad B \in \{\text{true}, \text{false}\}, \\ (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumProcess} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

8.33: Does not reject Cmsgs.msg.NumReceive > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad B \in \{\text{true}, \text{false}\}, \\ (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumReceive} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

8.34: Does not reject Cmsgs.msg.NumSend > Cmsgs.msg.Squadrons

Condition I:

$$\begin{aligned} \exists B, \quad B \in \{\text{true}, \text{false}\}, \\ (\exists f, 1 \leq f \leq \text{NArmy}[B], \\ (\exists m, m \in \{1 \dots \text{NCmsgs}[B]\}, \text{Mimp}(B, f, m, \text{Duration}))) \end{aligned}$$

Condition II:

$$\text{Cmsgs}[B, m].\text{msg}.\text{NumSend} > \text{Cmsgs}[B, m].\text{msg}.\text{Squadrons}$$

Condition III: True

8.36: Divide by zero in CalcContrast

Condition I:

$$\begin{aligned} &Active(B, g) \wedge Active(\neg B, e) \wedge \\ &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &BigEnough(B, g, j, e, k, Mainloop) \wedge Clear(B, g, j, e, k, Mainloop) \end{aligned}$$

Condition II:

$$\begin{aligned} &(X_{\neg B, e, k}(Mainloop) = 0 \vee Params.IX = 0) \wedge Params.IC = 0 \wedge \\ &(Y_{\neg B, e, k}(Mainloop) = 0 \vee Params.IY = 0) \wedge \\ &(Params.IAltFactor = 0 \vee \\ &Alt(X_{\neg B, e, k}(Mainloop), Y_{\neg B, e, k}(Mainloop)) = Params.IMeanAlt) \wedge \\ &Params.ISlopeFactor = 0 \end{aligned}$$

Condition III: True

8.37: Divide by zero in CalcAngle

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$\begin{aligned} &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &(X_{B, g, j}(Mainloop) = X_{\neg B, e, k}(Mainloop) - \frac{Army[\neg B, e].SquadWidth}{2} \vee \\ &X_{B, g, j}(Mainloop) = X_{\neg B, e, k}(Mainloop) + \frac{Army[\neg B, e].SquadWidth}{2}) \end{aligned}$$

Condition III: True

8.38: Missing equal-y case in FindAngle

Condition I: $Active(B, g) \wedge Active(\neg B, e)$

Condition II:

$$\begin{aligned} &\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge \\ &\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge \\ &(Y_{B, g, j}(Mainloop) = Y_{\neg B, e, k}(Mainloop) - \frac{Army[\neg B, e].SquadLength}{2} \vee \\ &Y_{B, g, j}(Mainloop) = Y_{\neg B, e, k}(Mainloop) + \frac{Army[\neg B, e].SquadLength}{2}) \end{aligned}$$

Condition III: True

8.40: Out-of-Bounds array reference in FindPoints

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge$
 $\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge$
 $\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge$
 $BigEnough(B, g, j, e, k, Mainloop)$

Condition II: $Params.SampleRate > 51$

Condition III: True

8.41: Divide by zero in Height

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge Params.SampleRate > 1 \wedge$
 $\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge$
 $\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge$
 $BigEnough(B, g, j, e, k, Mainloop)$

Condition II:

$X_{B,g,j}(Mainloop) = X_{\neg B,e,k}(Mainloop) \wedge Y_{B,g,j}(Mainloop) = Y_{\neg B,e,k}(Mainloop)$

Condition III: True

8.42: Divide by zero in Altitude

Condition I: $Active(B, g)$

Condition II: $Params.XDelta = 0 \vee Params.YDelta = 0$

Condition III: True

8.44: Divide by zero in CalcBI

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge$
 $\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge$
 $\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge$
 $BigEnough(B, g, j, e, k, Mainloop)$

Condition II: $Params.IMeanAlt = 0$

Condition III: True

8.45: Divide by zero in WeatherMoveEffect

Condition I: $Active(B, g)$

Condition II: $Params.WMaxSeverity = 0 \vee Params.NumWEvents = 0$

Condition III: True

8.46: Divide by zero in WObsEffect

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge Params.SampleRate > 2 \wedge$

$\exists j, 1 \leq j \leq Army[B, g].Squadrons, Endurance(B, g, j, Mainloop) > 0 \wedge$

$\exists k, 1 \leq k \leq Army[\neg B, e].Squadrons, Endurance(\neg B, e, k, Mainloop) > 0 \wedge$

$BigEnough(B, g, j, e, k, Mainloop)$

Condition II: $Params.WMaxSeverity = 0 \vee Params.NumWEvents = 0$

Condition III: True

8.48: Divide by zero in UpdateK

Condition I:

$Active(B, g) \wedge Params.NumWTypes > 0 \wedge$

$\exists w, 1 \leq w \leq Params.NumWTypes, NumWeapon(B, g, w, Mainloop) > 0 \wedge$

$\exists i, 1 \leq i \leq NumWeapon(B, g, w, Mainloop),$

$ax_{B,g,w,i}(Mainloop) \neq \infty \wedge ay_{B,g,w,i}(Mainloop) \neq \infty$

Condition II: $Army[B, g].Weapon[w].Radius = 0$

Condition III: True

8.50: Divide by zero in CalcRDelay

Condition I:

$Active(B, g) \wedge Active(\neg B, e) \wedge$

$(NCmsgs[B] > 0 \wedge$

$\exists m, 1 \leq m \leq NCmsgs[B], Mimp(B, g, m, Duration)) \vee$

$(Active(B, f) \wedge Army[B, f].Report = g \wedge$

$\exists t, 0 \leq t \leq Duration - RepT(B, f, g), SomeObserve(B, f, t))$

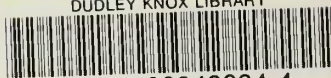
Condition II: $Army[\neg B, e].ComJamRadius = 0$

Condition III: True

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